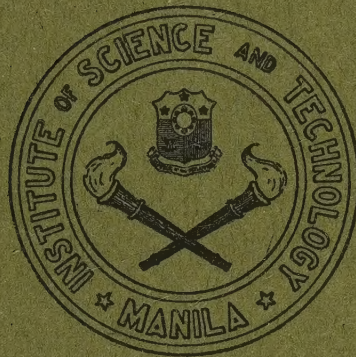


VOL. 81, No. 2

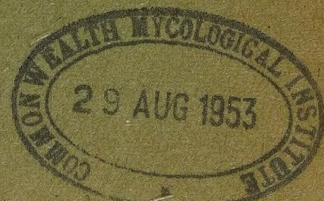
JUNE, 1952

THE PHILIPPINE JOURNAL OF SCIENCE



MANILA
BUREAU OF PRINTING
1953

23661



THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Institute of Science and Technology
(Formerly Bureau of Science)

JOAQUIN MARAÑON, D.Sc., *Editor*

EDUARDO QUISUMBING, Ph.D., *Associate Editor*

CONTRIBUTING EDITORS

Chemistry

MANUEL L. ROXAS, Ph.D.; F. T. ADRIANO, Ph. D.; R. H. AGUILAR, Ch.E.
PATROCINIO VALENZUELA, Ph.D.; MARCOS M. ALICANTE, Ph.D.
A. J. HERMANO, D.Sc.; FELIX V. ESPINO, Ch.E.

Geology

V. ELICAÑO, B.S.; ANTONIO D. ALVIR, Ph.D.; JOSE FELICIANO, Ph.D.

Experimental Medicine

DANIEL DE LA PAZ, M.D.; ARTURO GARCIA, M.D.; ONOFRE GARCIA, M.D.
CRISTOBAL MANALANG, M.D.; H. W. WADE, M.D.
WALFRIDO DE LEÓN, M.D.

Clinical Medicine

ANTONIO SISON, M.D.; AGERICO B. M. SISON, M.D.
LIBORIO GOMEZ, M.D., Ph.D.; H. LARA, M.D.
JOSE RODRIGUEZ, M.D.; CARMELO REYES, M.D.

Botany

ELMER D. MERRILL, D. Sc.; E. B. COPELAND, Ph.D.; A. F. FISCHER, C.E., M.F.
T. G. FAJARDO, Ph.D.; NICANOR G. TEODORO, Ph. D.
FELICIANO M. CLARA, Ph.D.; NEMESIO B. MENDIOLA, Ph.D.

Zoölogy

LEOPOLDO B. UICHANCO, D.Sc.; DEOGRACIAS V. VILLADOLID, Ph.D.
HERACLIO R. MONTALBAN, M.A.; GONZALO MERINO, Ph.D.
CANUTO G. MANUEL, D.Sc.; MANUEL D. SUMULONG, M.S., D.V.M.
LOPE M. YUTUC, D.V.M.; FAUSTINO Q. OTANES, M.S.
LEOPOLDO S. CLEMENTE, Ph.D.

Anthropology

H. O. BEYER, M. A.; RICARDO E. GALANG, M.A.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 81

JUNE, 1952

No. 2

MARIANO GATDULA BASACA

On October 4, 1951, Dr. Mariano Basaca, one of our foremost Filipino bacteriologists and Chief of the Biological Research Division, Institute of Science and Technology (formerly Bureau of Science), passed to the Great Beyond in line of duty. His death is a great loss not only to the medical profession but also to science, particularly in bacteriology to which he had dedicated his life.

Dr. Mariano Basaca was born in Cabuyao, Laguna, on July 15, 1893. He studied in the Ateneo de Manila and the University of Santo Tomas where he was conferred the degrees of Bachelor of Arts and Doctor of Medicine. After graduation he served as Junior and Assistant Bacteriologist in the Bureau of Science, and then in 1924 he was sent abroad as a fellow of the Bureau of Science. While in the United States he attended the Johns Hopkins University, Harvard Medical School and Chicago Rush Medical College from 1924 to 1926.

In 1926 he returned to the Philippines and resumed his research work in the Bureau of Science as Assistant Bacteriologist in the Biological Division and later as Assistant Scientist in charge of the Biological Research Laboratory. On July 1, 1941, he was promoted to the full rank of Scientist and sometime later became Chief of the Laboratory of the Department of Health and Welfare of the City of Manila. After the liberation in 1945 when the Bureau of Science was not yet rehabilitated, Dr. Basaca served as medical officer in the Bureau of Health and then was reinstated as Scientist in the Bureau of Science. Upon the transfer of the late Dr. Marcos A. Tubangui then Chief of the Division of Biological Research to the Institute of Hygiene in 1948, Dr. Basaca became con-

currently Acting Chief of the division and Scientist. On February 20, 1951, he became Chief of Division in the Institute of Nutrition and upon his return on July 1, 1951 to the Institute of Science and Technology, he was promoted to the position of Chief, Division of Biological Research, the position he held until his death.

Dr. Basaca was a member of the National Research Council, Manila Medical Society, Philippine Society of Parasitologists, and the Colegio Medico Farmaceutico de Filipinas, and was recognized as one of the leading bacteriologists in the Philippines. He had also written several technical papers published in the *Philippine Journal of Science* and in the *Proceedings of the Society of Experimental Biology and Medicine*.

The career of Dr. Basaca is a great inspiration to the young researchers of the Philippines; for as a leader in his field he was always helpful and kind to his younger associates. Above all, he was a religiously devoted worker until his death, despite difficulties. His deep understanding of human nature made him an advocate of social justice. Although engaged in research work he did not lose the common touch and preserved that natural glamour of his lifetime. He died a true career scientist.

JUAN MANALO

AMONG HIS CONTRIBUTIONS ARE THE FOLLOWING:

- BASACA, M. and OTTO SCHOBEL. Contribution to the serology of leprosy. *Philip. Jour. Sci.* 25 (1924) 1-9.
- BASACA, M., M. A. TUBANGUI and A. M. PASCO. Hexylresorcinol as an anthelmintic: its efficiency against the intestinal parasites of man. *Philip. Jour. Sci.* 54 (1934) 473.
- BASACA, M., M. A. TUBANGUI, A. M. PASCO and F. DEL ROSARIO. Human infestation with *Ascaris* and *Trichuris* in different parts of the Philippine Islands. *Philip. Jour. Sci.* 55 (1934) 91-113.
- BASACA, M., M. A. TUBANGUI and A. M. PASCO. Observations on the geographical distribution of hookworm parasites and hookworm disease in the Philippines. *Philip. Jour. Sci.* 58 (1935) 447.
- BASACA, M. and M. A. TUBANGUI. Notes on the anthelmintic properties of the latex of papaya (*Carica papaya* Linn.) and of "isis" (*Ficus ulmifolia* Lam.) *Philip. Jour. Sci.* 77 (1947) 19.
- BASACA, M. The production of yeast from molasses. *Philip. Jour. Sci.* 81 (1952) 75-79.



MARIANO GATDULA BASACA



Digitized by the Internet Archive
in 2025

PRODUCTION OF YEAST FROM MOLASSES *

By MARIANO G. BASACA

*Chief, Division of Biological Research
Institute of Science and Technology*

HISTORICAL REVIEW

The history of the yeast industry had its earliest development during ancient times. The Egyptians and Babylonians at that time were already familiar with the manufacture of flour, the making of bread and the fermentation of beer. The Egyptians had probably perfected baking and brewing a thousand or more years before the Christian Era. Bakers of the middle ages were well advanced in their technics. Regulations among bakers particularly as to the weight of bread existed then. In 1775 Krüntz stated that yeasts are bodies existing in the fluid during fermentation and are driven to the surface and later settled to the bottom—this is believed to be the first definite statement in the literature regarding the nature of the substance causing fermentation. In 1792 Mason, an Englishman, prepared the first compressed yeast. The first dried yeast was sold in Vienna in 1822 by Burka.

The modern compressed yeast industry may be considered to have begun about 75 years ago with the so-called Vienna process, by which yeast was propagated in a 15° to 20° Balling, unfiltered, and unaerated grain mash made from ground kiln-dried malt and corn grist. After 20 to 23 hours the yeast was skimmed off, washed and pumped to sifting machines in order to remove the undissolved portions of the grain. The yeast was then further washed and pressed. The yeast yield from this was 10 to 14 per cent of the grain used, while alcohol yield was 30 per cent. This process was later modified by the introduction of aeration, low temperature and the use of dilute worts to increase the yeast yield to about 40 per cent and decrease alcohol fermentation to 14 to 15 per cent.

It was only in or about 1915 that Hayduck was successful in producing yeast from molasses and ammonia through neutralization of the wort during the propagation period, the initiation of growth in dilute wort and the continuous addition thereto of concentrated wort at a rate such that any alcohol formed is assimilated by the yeast during its growth. Yield

* Preliminary report.

of yeast as high as 200 per cent based on the amount of sugar in the wort have been obtained.

The production of yeast has already been highly commercialized in many countries especially in the United States but not in the Philippines. An attempt towards this direction in this country was made in 1949 in response to the national campaign of food production. It was thought that the high content of yeast may contribute to solve the food shortage problems. To produce meat from animals it requires months and years, cereals—months, vegetables—weeks, while yeast needs only hours or days. It was found out that during World Wars I and II, Germany resorted to this kind of food. The American Army in the last war was well supplied with food yeast. Yeast is not only necessary as a source of protein in times of emergency but also in times of peace especially when natural protein foods are very expensive.

MATERIALS AND METHODS

The method used was based on the paper of Arthur J. Nolte³ et al on "Feed-Yeast and Industrial Alcohol from Citrus-Waste Press Juice."

Torulopsis utilis was used due to its rapid multiplication which is three times as rapid as baker's yeast and its low production of alcohol. Furthermore, *T. utilis* has the ability to assimilate pentoses and to synthesize Vitamin B complex, nicotinic acid and glutathione from sugar and mineral salts in nutritive media.

Molasses was used as the main source of sugar for yeast culture because of its abundance in the Philippines and Trisodium phosphate and ammonium sulfate as nutrients.

Preparation of seed.—From pure stock culture of *T. utilis*, transplant was made into 12 large tubes of Sabourand's maltose agar slants and after 48 hours at room temperature, the growth was washed off and inoculated into the propagating wort.

Pretreatment of molasses.—250 cc of molasses were diluted with an equal part of water and 1.6 cc concentrated H_2SO_4 CP added. The mixture was sterilized for 40 minutes at 15 lbs. pressure. The sugar content of this dilution was about 30 per cent based on total sugar content of raw molasses with a total sugar content of 60 per cent based on Fehling's test. This was filtered through a super-centrifuge to remove the organic matter in suspension which imparted a dark color to the yeast and to eliminate the calcium salts which remained in suspen-

sion. Excessive calcium salts in the medium produces a deleterious effect on the growth of yeast.

Actual propagation.—The above mixture was diluted to 13 liters with tap water and 50 cc of $N1\ H_2SO_4$ added. The clear filtrate was placed in a glass container or propagation vat and after adding 14.6 grams of amonium sulfate and 12.6 grams of trisodium phosphate the set up was ready for the addition of the seed. Every hour afterwards for six times, 3 grams of ammonium sulfate were added. Four hours after the start of the propagation 6 grams of sodium carbonate were added and again 2 hours afterwards.

Aeration was effected by means of a regular Mandler filter No. 3-5" x 1" test 4 lbs. pressure connected directly to an air pump and provided with a cotton filter and the pressure or amount of flow of air was regulated. Aeration was necessary to replace dissolved oxygen. It is also believed that aeration takes away fermented products from the surface of the cells and substitutes fresh nutrients for them. Agitation also increased yeast yield.

The addition of sodium carbonate was necessary to maintain the pH of the wort between 4.4 and 6.5.

At the end of eight hours the propagation was stopped. It was then passed through a supercentrifuge. The sediment was washed with tap water and centrifuged at 3500 r.p.m. for 30 minutes. The sediment was then placed in a double boiler for 6 hours to remove some of the moisture. Then it was placed in a vacuum oven at 70°C for 2 to 3 days.

The dried yeast was ground through a corn mill and further pulverized in a hand stone mortar. The finished product was stored in bottles and kept in the incubator at 37°C to avoid absorption of moisture.

Results.—The average yield in 32 runs of this propagation was 285 grams of dry yeast or 190 per cent based on total sugars of the wort (150 gm.) or 570 per cent based on seed (50 gms.) The highest yield was 300 gms. of dry yeast or 200 per cent based on total sugars or 600 per cent based on seed.

A composite powdered yeast of several runs was examined chemically by standard test and the following results were obtained:

	Per cent		Per cent
Moisture	7.5	Moisture free (dried to 100°C)	
Protein	48.2		52.1

	Per cent	Per cent
Glycogen	12.5	13.52
Fat.....	4.33	4.7
Ash	6.2	6.7

Minerals or ash

Calcium as calcium oxide	0.9
Manganese	4.2
Phosphorus as P_2O_5	44.6
Sodium oxide and potassium oxide	37.71

Discussion.—The writer believes that with better equipment and apparatus the yeast yield from molasses using the above procedure can be still increased. The composition of the yeast obtained did not vary much from that obtained by Nolte, as shown by the accompanying table of comparison:

Comparative composition of yeast

	By Nolte method Per cent	This method Per cent
Moisture	1.29	Moisture free
Protein	52.28	52.1
Glycogen	12.78	13.52
Fat	4.51	4.7
Ash	8.08	6.7

The composition of yeast as compared with that of common vegetable foods, is remarkable for its high content of protein and glycogen and its low fat. According to F. O. Reed, this yeast when added to cereal foods has been shown to improve the nutritive value greatly by supplying the amino acids which are deficient in cereal proteins. As little as 0.5 oz. per day would sufficiently enrich the normal diet. Food yeast is not eaten in powder form. It is added to food with no change or just a slight effect on the taste. The taste is rather conventional, the odor is similar to malted foods and the color is light brown. These characteristics of yeast powder make it acceptable as a food supplement.

Conclusion.—The low cost of production, the short time required to propagate yeast so that if it is necessary a 24-hour run or a shift of every 8 hours can be easily done, its high nutritive value as a food supplement—all these should encourage the establishment of a pilot plant so that food yeast can be produced in large scale.

ACKNOWLEDGMENT

The writer wishes to acknowledge the services of Miss Dolores Hipolito who was responsible for the chemical analysis of the yeast. The writer is likewise deeply indebted to Mr.

Benisio Leonen who rendered invaluable service, who many a time had to work beyond call of duty so that this project may be carried out successfully.

REFERENCES

1. FREY, C. N. History and development of the modern yeast industry. *Ind. Eng. Chem.* **22** (1930) 1154-1162.
2. FREY, G. N. *et al.* Yeast. Physiology, manufacture and uses. *Ind. Eng. Chem.* **28** (1936) 879-884.
3. NOLTE, A. J. *et al.* Feed yeast and industrial alcohol from citrus-waste press juice. *Ind. Eng. Chem.* **34** (1942) 670-673.
4. OWEN, W. L. Blackstrap molasses as raw material for biochemical industries. VIII—Compressed yeast. Yeast manufacture for cattle feed and baking industry offers largest opportunities for development. *Facts About Sugar* **32** (1937) 263-265.
5. REED, F. O. Food yeast production. *Intern. Sugar Jour.* **50** (1948) 128-130.
6. SKINNER, C. E. *et al.* *Henrici's Molds, Yeasts, and Actinomycetes.* New York, John Wiley and Sons, Inc. 2nd ed. (1947) 409 p.
7. STUBBS, J. J. *et al.* Fruit juices yield food yeast. *Food Ind.* **16** (1944) 694-696.
8. SURE, B. and F. HOUSE. Protein utilization of various dried food yeasts. *Archives of Biochemistry* **20** (1949) 55-58.
9. WOOD, M. New food for hungry millions. Food yeast, a miracle of nature, may free the world from the threat of starvation. *Philip. Dept. Agric. Nat. Res. News Bull.* **2** 9-10 (1947) 13-17.

GRAMMITIDACEÆ OF NEW GUINEA *

By EDWIN BINGHAM COPELAND
Of the University of California

TEN PLATES

This paper is in part a report on the ferns collected by the third Archbold Expedition to New Guinea, in collaboration with the Government of Netherlands Indies. The previous reports were published in the Philippine Journal of Science 73 (1940) 345 and 457; 75 (1941) 347; 76 (1941) 23; and 78 (1949) 207; and Univ. Calif. Publ. Bot. 18 (1942) 217.

A report on this group of ferns was prepared in 1939 and 1940, and submitted for publication on May 10, 1940. Proof was read and returned September 1, 1941. It then became a casualty of war. To guard the new names, these were published, with brief, merely legal diagnosis, in Univ. Calif. Publ. Bot. 18 (1942) 217-226. The descriptions and illustrations, necessary to make these novelties certainly and easily recognizable, were published as to the genus *Grammitis* in my monograph of that genus, Philip. Jour. Sci. 80 (1951) 95. As to the other genera, they appear here for the first time.

Key to the genera

- Sori protected by folding of fertile segment.
Protective fold free 4. *Calymmodon*
Fold fused over sorus 5. *Acrosorus*
Sori not protected by folding of segment.
Sporangia in round or oblong sori.
Fronds simple or shallowly lobed 1. *Grammitis*
Fronds pinnatifid or pinnate.
Veins in segments simple or forked 3. *Xiphopteris*
Veins pinnate in segment or pinna.
Sori dorsal 6. *Ctenopteris*
Sori immersed in or near margin 7. *Prosaptia*
Sori in elongate coenosori.
Sori parallel to costa, vein free 2. *Scleroglossum*
Sori normally oblique to costa, venation reticulate.. 8. *Loxogramme*

* During the past decade, our ideas as to the systematic status of this group have changed materially. Accordingly, I have rewritten this paper treating what was definite but nameless group as a family, coordinate with Polypodiaceæ in the present restricted sense.

I. GRAMMITIS Swartz

As this genus has recently been monographed, it may suffice to present here a key to the New Guinea species and an enumeration.

Key to the species

Stipes naked or glabrescent.

Sori superficial or nearly so.

Stipe at least half as long as lamina 1. *G. caricifolia*

Stipe relatively short.

Lamina not over 5 cm long 2. *G. oblanceolata*

3. *G. reducta*

P. viridulum

Lamina 7 to 15 cm long 4. *G. stanleyana*

Lamina longer.

Fronds 3 mm wide 5. *G. graminifolia*

Fronds 5 to 6 mm wide 6. *G. frigida*

Fronds 10 to 12 mm wide.

Stipe 0 to 2 cm long 7. *G. subfasciata*

Stipe 3 to 8 cm long 8. *G. integra*

Sori impressed or immersed.

Stipe longer than fertile lamina 10. *G. interrupta*

Stipe shorter than lamina.

Stipe 4 cm long or longer.

Sori in deep clefts 14. *G. locellata*

Sori in deep clefts 11. *G. plurisetulosa*

Stipe 0 to 2 cm long.

Soral pits close together 9. *G. pleurogrammoides*

Soral pits not contiguous.

Borders of pits naked 12. *G. loculosa*

Borders of pits hairy 13. *G. dictymioides*

Stipes hairy.

Bases of stipe-hairs enlarged.

Sori impressed, uniseriate 16. *G. scabristipes*

Sori superficial, some scattered 17. *G. novoguineensis*

Bases of hairs not enlarged.

Fronds small, thin, paleae undeveloped.

Hairs of frond under 0.5 mm long 18. *G. coredrosora*

Hairs over 1 mm long 19. *G. parva*

Fronds mostly larger, paleae developed.

Sori deeply immersed.

Soral pits open, oblong 12. *G. loculosa*

Pits linear, opening at maturity 15. *G. stomatocarpa*

Sori superficial or moderately impressed.

Stipes velutinous, hairs up to 0.6 mm long.

Veins normally once forked 20. *G. mesocarpa*

Veins forked more than once.

Sori rather scattered 21. *G. sumatrana*

Sori regularly seriate 22. *G. subrepanda*

P. torricellianum

P. carstensense.

- Stipes with deciduous short hairs..... 6. *G. frigida*
Hairs of stipe 1 mm long or longer.
Laminar surface naked.
Veins simple 26. *P. sucklingianum*
Veins once forked, veinlets equal.
Stipe densely hairy 27. *G. ciliolata*
Stipe sparsely hairy 28. *G. ceratocarpa*
Veinlets more numerous, unequal.
Stipe sparsely hairy.
Stipe 5 to 10 cm long..... 24. *G. Archboldii*
Stipe 1 to 2 cm long..... 25. *P. diplosoroides*
Stipe moderately hairy 29. *G. dolichosora*
Stipe densely hairy 47. *G. knutsfordiana*
Laminar surface more or less setose.
Sori partly scattered 23. *G. subreticulata*
Sori strictly uniseriate.
Fronds sessile 30. *P. papuense*
Fronds stipitate.
Fertile veinlet ending in sorus.
Veins once forked..... 31. *G. Mariae*
Margin inciso-crenate.....
Margin entire.
Fronde 10 cm by 3 mm .. 32. *G. hirtiformis*
Fronde 10 cm by 7 mm 33. *G. matapensis*
Fronde much larger..... 39. *G. ornaticissima*
Veins twice forked.
Hairs sparse and long 47. *G. knutsfordiana*
Bristles minute, dense..... 48. *G. hispida*
Fertile veinlet prolonged.
Stipe $\frac{1}{10}$ as long as lamina.
Fronde densely hairy 38. *G. habbemensis*
Fronde sparsely hairy 37. *G. inconstans*
Stipe relatively long.
Fronde ca. 3 cm long 46. *G. murrayana*
Fronde larger.
Veins once forked.
Veins at about 45°.
Fronds moderately hairy.
Densely ciliate.. 42. *G. cyclosora*
Sparsely ciliate.
Veins approaching margin 35. *G. Myer-Dreesii*
Veins far from margin 36. *G. brevisetulosa*
Fronds extremely hairy 41. *G. trogophylla*
Veins at an acute angle.
Stipe weak 34. *G. debilifolia*
Stipe firm 40. *G. mollipila*
Veins more divided.

Apex attenuate.	
Paleae brown	43. <i>G. trichopoda</i>
Paleae black	44. <i>G. nigropaleata</i>
Apex abrupt	45. <i>G. fasciculata</i> .
Monstrosities with repeatedly forked fronds	<i>P. fuciforme</i>
	<i>P. alpicorne</i>
	<i>P. dichotoma</i>

1. **GRAMMITIS CARICIFOLIA** Copel.

G. caricifolia COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 166.

Mt. Sarawaket, *Clemens*; Mt. Wilhelmina, *Brass 9410*.
Alpine.
Endemic.

2. **GRAMMITIS OBLANCEOLATA** (Baker) Copel.

G. oblanceolata (Baker) COPEL., Philip. Jour. Sci. 80 (1951) 166.
Polypodium oblanceolatum BAKER, Ann. of Bot. 8 (1894) 128.

Mt. Suckling, *MacGregor*; *Carr 13665*.
Endemic.

POLYPODIUM VIRIDULUM v.A.v.R.

Polypodium viridulum v.A.v.R., Nova Guinea 14 (1924) 41.

Doorman Summit, alt. 2,500 m.

I have not seen this, and, by description, do not distinguish it from *G. oblanceolata*.

3. **GRAMMITIS REDUCTA** (v.A.v.R.) Copel.

G. reducta (v.A.v.R.) COPEL., Philip. Jour. Sci. 80 (1951) 167.
Polypodium reductum v.A.v.R., Nova Guinea 14 (1924) 41.

Near Doorman Summit, alt. 1,420 m, *Lam 1549, 1550*. There are forked fronds in both collections.
Endemic.

4. **GRAMMITIS STANLEYANA** (Baker) Copel.

G. stanleyana (Baker) COPEL., Philip. Jour. Sci. 80 (1951) 168.
Polypodium stanleyanum BAKER, Jour. Bot. 28 (1890) 107.
P. trichocarpum v.A.v.R., Nova Guinea 14 (1924) 41.

Apparently common at major altitudes; epiphytic and terrestrial.
Endemic.

5. **GRAMMITIS GRAMINIFOLIA** Copel.

G. graminifolia COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 169.

Mt. Tafa, alt. 2,400 m, *Brass 5092*; Lake Habbema, alt. 3,225 m, *Brass 9111*. Terrestrial.
Endemic.

6. **GRAMMITIS FRIGIDA** (Ridley) Copel.

G. frigida (Ridley) COPEL., Philip. Jour. Sci. 80 (1951) 170.

Polypodium frigidum RIDLEY, Trans. Linn. Soc. Bot. 9 (1916) 259.

DUTCH NEW GUINEA, alt. 3,500 m, *Boden Kloss*; Bele River, alt. 2,200 m, *Brass 11272, 11267*.

Endemic.

7. **GRAMMITIS SUBFASCIATA** (Ros.) Copel.

G. subfasciata (Ros.) COPEL., Philip. Jour. Sci. 80 (1951) 170.

Polypodium subfasciatum Ros., Fedde's Repert. 5 (1908) 41.

Mt. Gelu, alt. 1,000 m, *Werner 25*.

Endemic.

8. **GRAMMITIS INTEGRATA** (Brause) Copel.

G. integra (Brause) COPEL., Philip. Jour. Sci. 80 (1951) 171.

Polypodium integrum BRAUSE, Engl. Jahrb. 49 (1912) 37.

GERMAN NEW GUINEA, alt. 1,200 m, *Schulze*; Lake Habbema, alt. 3,225 m, *Brass 9358*, epiphytic or terrestrial.

Endemic. Possibly the same as *G. subfasciata*.

9. **GRAMMITIS PLEUROGRAMMOIDES** (Ros.) Copel.

G. pleurogrammoides (Ros.) COPEL., Genera (1947) 213; Philip. Jour. Sci. 80 (1951) 172.

Polypodium pleurogrammoides Ros., Fedde's Repert. 5 (1908) 42.

Mt. Gelu, alt. 1,700 m, *Werner 22*; Idenburg River, alt. 1,600 m, *Brass 12734*.

This species may represent the ancestry of *Scleroglossum*.

Endemic.

10. **GRAMMITIS INTERRUPTA** (Baker) Copel.

G. interrupta (Baker) COPEL., Genera (1947) 214.

Monogramma interrupta BAKER, Annals Bot. 5 (1891) 482.

Pleurogramme interrupta CHRIST, Farnkr. der Erde (1897) 55.

Nematopteris interrupta C. CHR., Dansk bot. Arkiv. 6 (1929) 31.

Polypodium pyxidiforme v.A.v.R., Bull. Jard. Buit. II 1 (1911) 29.

Mt. Yule; Dutch New Guinea, *Lam 1051*; Idenburg River, alt. 2,000 m, *Brass 11863, 12603*.

Endemic.

11. **GRAMMITIS PLURISSETULOSA** Copel.

G. plurisetulosa COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 174.

Mt. Wilhelmina; Mt. Bolan; Mt. Sarawaket; Mt. Albert Edward. Alpine.

Endemic.

12. **GRAMMITIS LOCULOSA** (v.A.v.R.) Copel.

G. loculosa (v.A.v.R.) COPEL., U. C. Publ. Bot. 18 (1942) 223;
Philip. Jour. Sci. 80 (1951) 175.

Polypodium loculosum v.A.v.R., Nova Guinea 14 (1924) 42.

Doorman River, alt. 200 m, *Lam* 1267.

Endemic.

13. **GRAMMITIS DICTYMIOIDES** Copel.

G. dictymioides COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip.
Jour. Sci. 80 (1951) 175.

Lake Habbema, alt. 3,225 m, *Brass* 11848, 9375, 9059.

Anastomosing veins are common.

Endemic.

14. **GRAMMITIS LOCELLATA** (Baker) Copel.

G. locellata (Baker) COPEL., U. C. Publ. Bot. 18 (1942) 223;
Philip. Jour. Sci. 80 (1951) 176.

Polypodium locellatum BAKER, Philip. Jour. Sci. 80 (1951) 176.

Mt. Victoria; Mt. Sarawaket, *Clemens*.

Endemic.

15. **GRAMMITIS STOMATOCARPA** Copel.

G. stomatocarpa COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip.
Jour. Sci. 80 (1951) 177.

Mt. Wilhelmina, in subalpine forest, alt. 3,650 m. *Brass*
9858a; 9630; Lake Habbema, alt. 3,225 m, *Brass* 9219.

Endemic.

16. **GRAMMITIS SCABRISTIPES** (Baker) Copel.

G. scabristipes (Baker) COPEL., U. C. Publ. Bot. 18 (1942) 223;
Philip. Jour. Sci. 80 (1951) 178.

Polypodium scabristipes Baker, Jour. Bot. 28 (1890) 108.

Apparently common at major altitudes.

Endemic.

17. **GRAMMITIS NOVOGUINEENSIS** Copel.

G. novoguineensis COPEL., U. C. Publ. Bot. 18 (1942) 22; Philip.
Jour. Sci. 80 (1951) 178.

Polypodium diplosorum f. *grammitoides* ROS. in herb.

Bolan, alt. 3,400 to 3,800 m, *Bamler B* 41; *Keysser B* 1; the
latter collection bears pinna-like lateral outgrowths up to 4 cm
long.

Endemic.

18. **GRAMMITIS COREDROSORA** (v.A.v.R.) Copel.

G. coredrosora (v.A.v.R.) COPEL., Philip. Jour. Sci. 80 (1951) 179.
Polypodium coredrosorum v.A.v.R., Nova Guinea 14 (1924) 44.

Ridge near Doorman Summit, alt. 1,420 m, *Lam* 1550a.

Endemic.

19. GRAMMITIS PARVA (Brause) Copel.

G. parva (Brause) COPEL., Genera (1947) 211; Philip. Jour. Sci. 80 (1951) 180.

Polypodium parvum BRAUSE, Engl. Jahrb. 49 (1912) 36.

Finisterre and Kani ranges, alt. 1,000 m, *Schlechter 18033* and *17156*. Carr 13525, from Boridi, is referred to this species by Alston.

Endemic.

20. GRAMMITIS MESOCARPA (v.A.v.R.) Copel.

G. mesocarpa (v.A.v.R.) COPEL., Philip. Jour. Sci. 80 (1951) 181.

Polypodium mesocarpum v.A.v.R., Nova Guinea 14 (1924) 42.

Doorman Summit, alt. 1,420 to 1,450 m, *Lam 1487*, *1878*, *Brass 12009*, from Idenburg River region, alt. 1,800 m, probably represents this species.

Endemic.

G. adspersa (Blume) Copel. (as *Polypodium malaicum*) is reported from the Hellwig Mountains by Rosenstock, Nova Guinea 8 (1912) 725, the specimen being *v. Roemer 1168*. This species is common farther West, but I have not seen it from New Guinea.

21. GRAMMITIS SUMATRANA (Baker) Copel.

G. sumatrana (Baker) COPEL., Philip. Jour. Sci. 56 (1935) 97; 80 (1951) 181.

Polypodium sumatranum BAKER, Journal Bot. 18 (1880) 214.

P. serraeforme BRAUSE, Engl. Jahrb. 49 (1912) 36, non J. Sm.

P. brauseanum v.A.v.R., Malayan Ferns Suppl. (1917) 521.

P. biseriale RIDLEY, Trans. Linn. Soc. Bot. II 9 (1916) 260.

Finisterre Mts. alt. 950 m, *Schlechter 18142*, type collection of *P. serraeforme*.

JAVA; SUMATRA; PHILIPPINES.

22. GRAMMITIS SUBREPANDA (Brause) Copel.

G. subrepanda (Brause) COPEL., Philip. Jour. Sci. 80 (1951) 183.

Polypodium subrepandum Brause, Engl. Jahrb. 49 (1912) 37.

German and Dutch New Guinea, many collections, alt. 1,200 to 2,800 m.

Endemic (or possibly in Borneo).

Doubtfully distinct from this species are *Polypodium torricellianum* Brause, Engl. Jahrb. 49 (1912) 45, f. 3 A, and *P. carstenszense* Ridley, Trans. Linn. Soc. Bot. II 9 (1916) 260.

23. GRAMMITIS SUBRETICULATA Copel.

G. subreticulata COPEL., Philip. Jour. Sci. 80 (1951) 185.

Polypodium subreticulatum COPEL., Philip. Jour. Sci. § C 9 (1914) 6.

Taupota, Papua, King 395, 1. Shaw.

Known by a single collection.

24. **GRAMMITIS ARCHBOLDII** (C. Chr.) Copel.

G. Archboldii (C. Chr.) COPEL., Philip. Jour. Sci. 80 (1951) 186.

Polypodium Archboldii C. CHR., Brittonia 2 (1937) 305.

Mt. Albert Edward, alt. 3,680 m, Brass 4236, 4259; Mt. Tafa, alt. 2,400 m, Brass 5093.

Endemic.

25. **POLYPODIUM DIPLOSOROIDES** Ros.

Polypodium diplosoroides ROS., Nova Guinea 8 (1912) 724.

Hellwig Mts., alt. 1,350 to 1,600 m, v. Roemer nos. 1167, 1317.

Endemic.

26. **POLYPODIUM SUCKLINGIANUM** Baker

Polypodium sucklingianum BAKER, Annals Bot. 8 (1894) 128.

Mt. Suckling, received by MacGregor from F. Mueller.

Endemic.

I have not seen this or the preceding species, and hesitate to transfer their names.

27. **GRAMMITIS CILIOLATA** (v.A.v.R.) Copel.

G. ciliolata (v.A.v.R.) COPEL., Philip. Jour. Sci. 80 (18951) 117.

Polypodium ciliolatum v.A.v.R., Nova Guinea 14 (1924) 43.

Near Doorman Summit, alt. 1,420 m, Lam 1518.

Endemic.

28. **GRAMMITIS CERATOCARPA** Copel.

G. ceratocarpa COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 188.

Morobe, alt. 3,000 m, Clemens 11349.

Endemic.

29. **GRAMMITIS DOLICHOSORA** Copel.

G. dolichosora COPEL., Philip. Jour. Sci. 80 (1951) 188.

Polypodium dolichosorum COPEL., Philip. Jour. Sci. 1 Suppl. (1906) 159, pl. 16.

Nassau Mts., v. Leeuwen 10939; Sepik region, Ledermann.

MINDANAO; BORNEO.

30. **POLYPODIUM PAPUENSE** v.A.v.R.

Polypodium papuense v.A.v.R., Malayan Ferns Suppl. (1917) 521.

P. papuanum Ridley, Trans. Linn. Soc. Bot. 9 (1916) 261, non Baker.

DUTCH NEW GUINEA, alt. 2,500 feet.

Unknown to me.

31. **GRAMMITIS MARIAE** Copel.

G. Mariae COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 189.

Morobe, alt. 8,000 to 10,000 feet, *Clemens 10251a*; Rawlinson range, alt. 12,000 feet, *Clemens*.

Endemic.

32. **GRAMMITIS HIRTIFORMIS (Ros.) Copel.**

G. hirtiformis (ROS.) COPEL., Philip Jour. Sci. 80 (1951) 190.

Polypodium hirtiforme Ros., Fedde's Repert. 12 (1913) 176.

Bolan Mts., alt. 2,400 to 3,000 m, *Keysser B 48*.

Endemic .

33. **GRAMMITIS MATAPENSIS Copel.**

G. matapensis COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 191.

Morobe, alt. 1,700 m, *Clemens 11176*.

Endemic.

34. **GRAMMITIS DEBILIFOLIA Copel.**

G. debilifolia COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 191.

Mt. Wilhelmina, alt. 3,800 m, *Brass and Myer-Drees 10036*.

Here, *vide* Alston, belong also *Carr 15130*, and *Clemens 7343*, 6236, and 6233, from Mt. Sarawaket.

Endemic.

35. **GRAMMITIS MYER-DREESII Copel.**

G. Myer-Dreesii COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 192.

Near Mt. Wilhelmina, alt. 3,580 m, *Brass and Myer-Drees 9898*.

Endemic.

36. **GRAMMITIS BREVISETULOSA Copel.**

G. brevisetulosa COPEL., U. C. Publ. Bot. 18 (1942) 223.

Morobe, alt. 1,700 m, *Clemens*.

Endemic.

37. **GRAMMITIS INCONSTANS (v.A.v.R.) Copel.**

G. inconstans (v.A.v.R.) COPEL., Philip. Jour. Sci. 80 (1951) 193.

Polypodium inconstans v.A.v.R., Nova Guinea 14 (1924) 43.

Near Doorman Summit, alt. 1,450 m, *Lam 1882*.

Endemic.

38. **GRAMMITIS HABBEMENSIS Copel.**

G. habbemensis COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip. Jour. Sci. 80 (1951) 194.

Near Lake Habbema, alt. 2,860 m, *Brass 10520*.

Endemic.

Alston believes this to be *G. oblanceolata*.

39. GRAMMITIS ORNATISSIMA (Ros.) Copel.

G. ornatissima (Ros.) COPEL., Philip. Jour. Sci. 80 (1951) 195.

Polypodium ornatissimum Ros., Fedde's Repert. 5 (1908) 41.

Mt. Gelu, alt. 1,000 m, *Werner 47; v. Roemer 734, fide Rosenstock.*

Endemic.

Brause, Engl. Jahrb. 56 (1920) 180, describes var. *dichotomum*, with narrow, dichotomous fronds; *Ledermann 11809.*

40. GRAMMITIS MOLLIPILA (Baker) Copel.

G. mollipila (Baker) COPEL., U. C. Publ. Bot. 18 (1942) 224;

Philip. Jour. Sci. 80 (1951) 195.

Polypodium mollipilum BAKER, Jour. Bot. 28 (1890) 107; Christensen, Brittonia 2 (1937) 305.

Near Mt. Wilhelmina, alt. 3,580 m, *Brass and Myer-Drees 9841 (?)*.

Endemic.

41. GRAMMITIS TROGOPHYLLA Copel.

G. trogophylla COPEL., U. C. Publ. Bot. 18 (1942) 224; Philip Jour. Sci. 80 (1951) 196.

Mt. Sarawaket, alt. 9,000 to 12,000 feet, *Clemens 10087* and *s. n.*; *Brass 9855*, from Mt. Wilhelmina, is approximately the same.

Endemic.

42. GRAMMITIS CYCLOSORA Copel.

G. cyclosora COPEL., U. C. Publ. Bot. 18 (1942) 224; Philip. Jour. Sci. 80 (1951) 197.

Mt. Sarawaket, alt. 11,000 to 12,500 feet, *Clemens.*

Endemic.

43. GRAMMITIS TRICHOPADA (Mueller and Baker) Copel.

G. trichopoda (Mueller and Baker) COPEL., U. C. Publ. Bot. 18 (1942) 224; Philip. Jour. Sci. 80 (1951) 197.

Polypodium trichopodum F. MUELLER, Trans. R. Soc. Victoria 1 (1889) 40; Jour. Bot. 28 (1890) 107; C. CHR., Brittonia 2 (1937) 305.

Mt. Albert Edward, alt. 3,680 m, *Brass 4260.*

Var. *serrato-lobatum* Brause, Engl. Jahrb. 56 (1920) 179, from the Sepik region, alt. 1,150 m, *Ledermann 11576*, is peculiar in several respects, permitting doubt that it belongs in this species.

Endemic.

44. GRAMMITIS NIGROPALEATA Copel.

G. nigropaleata COPEL., U. C. Publ. Bot. 18 (1942) 223; Philip Jour. Sci. 80 (1951) 198.

Morobe, alt. 1,700 m, *Clemens 41018*.

Endemic.

45. GRAMMITIS FASCICULATA Blume

G. fasciculata BLUME, *Flora Javæ* 2 (1828) 112, *plate 47, f. 2*;
Philip. Jour. Sci. 80 (1951) 198.

Mt. Wilhelmina, alt. 4,050 m, in rock hole in open grassland;
Brass and Myer-Drees 10042A.

Malay and Philippines; common and showy.

46. GRAMMITIS MURRAYANA (C. Chr.) Copel.

G. murrayana (C. Chr.) COPEL., Philip Jour. Sci. 80 (1951) 200.
Polypodium murrayanum C. CHR., *Brittonia* 2 (1937) 304.

Wharton Range, alt. 2,840 m, *Brass 4726*.

Endemic.

47. GRAMMITIS KNUTSFORDIANA (Baker) Copel.

G. knutsfordiana (Baker) COPEL., U. C. Publ. Bot. 18 (1942) 224;
Philip. Jour. Sci. 80 (1951) 201.

Polypodium knutsfordianum Baker, *Journal of Bot.* 28 (1890) 107;
Annals of Bot. 8 (1894) 128.

Apparently common. The veins are very conspicuous.

BATJAN; MINDANAO; BORNEO.

48. GRAMMITIS HISPIDA Copel.

G. hispida COPEL., U. C. Publ. Bot. 18 (1942) 224; Philip Jour. Sci.
80 (1951) 203.

Near Lake Habbema, alt. 2,800 m, *Brass 10257, 10284*.

Endemic.

POLYPODIUM FUCIFORME Ros.

P. fuciforme ROS., *Nova Guinea* 8 (1912) 726.

P. dichotomum BRAUSE, *Engl. Jahrb.* 56 (1920) 190, *nec aliorum*.

P. allicorne RIDLEY, *Trans. Linn. Soc. Bot.* 9 (1916) 261, *non Baker*.

These three are apparently monstrosities, and do not represent proper species.

2. SCLEROGLOSSUM van Alderwerelt van Rosenburgh

Christensen, *Dansk bot. Arkiv* 6 2 (1929), reports from New Guinea *S. debile* (Kuhn) v.A.v.R., *S. pusillum* (Blume) v.A.v.R. and a variety *angustissimum* (Copel.) C. Chr., and *S. sulcatum* (Kuhn) v.A.v.R., and presents a key for their discrimination:

Leaf-edge outside the groove attenuate towards the margin.

Small (2-3 cm by 1-2 mm); most veins simple; leaf-edge outside the groove about as broad as the costal parenchyma 1. *S. debile*

Larger (5-10 cm by 3-4 mm); leaf-edge at most half as broad as costal parenchyma 2. *S. pusillum*

Leaf-edge thick, angular or round 3. *S. sulcatum*

Christensen's treatment is unsatisfactory to its author, and probably no less so to me, but it does make clear the difficulty of distinguishing species in this genus. My presentation, which follows, is likewise unsatisfactory.

Sorus marginal or nearly so.

- | | |
|--|---------------------------------------|
| Fertile portion of frond not dilated | 1. <i>S. debile</i> |
| Fertile portion abruptly dilated | 2. <i>S. juncifolium</i> |
| Sorus nearer to costa than to margin | 3. " <i>T.</i> " <i>simplicivenia</i> |

1. **SCLEROGLOSSUM DEBILE** (Kuhn) v.A.v.R.

S. debile (Kuhn) v.A.v.R., Bull. Jard. Buit. II 1 (1912) 39.

Vittaria debilis Kuhn, Linnaea 36 (1869) 67.

Palmer River, alt. 100 m, *Brass* 7167; Kari Mts., alt. 1,000 m, *Schlechter* 17198.

BORNEO; MALAYA.

Not certainly distinct from *S. pusillum*.

S. pusillum may be represented by *Brass* 9329, Lake Habbema, alt. 3,225 m, on rocks in grassland; a dwarfed plant.

2. **S. JUNCIFOLIUM** Copel., sp. nov.

S. rhizomate adscendente, paleis fuscis, minutis; frondibus dense fasciculatis, usque ad 12 cm longis, 1-1.8 mm latis, apiculatis, deorsum usque ad rhizoma attenuatis, coriaceis, parte fertile subapicale 2-5 cm longa 2-2.5 mm lata, soro fere marginale.

Brass 11864, type, SW. of Bernhard Camp, Idenburg River, alt. 1,800 m; *No.* 12602, alt. 2,150 m; common on branches of tall trees. Here probably belongs also *Clemens* 41006, Matap, Morobe District, alt. 5,000 to 6,000 feet; smaller than type, with more dilated fertile portion.

I propose a new name reluctantly, in this genus of dubious species, but the plants seem really distinct. *S. pusillum*, as represented by my own collection on the Gedeh (type locality), has less closely marginal sori, and non-dilated fertile portion of the frond. The closest resemblance of the new species is to *S. minus* (Fée) C. Chr., common in the Philippines and ascribed to Amboyna by Christensen, also with hardly dilated fertile portion.

S. juncifolium may possibly be *Pleurogramme loheriana* var. *novoguineensis* Ros., Nova Guinea 8 (1912) 729, and/or *Scleroglossum pusillum* var. *novoguineense* v.A.v.R., Malayan Ferns Suppl. (1917) 340. Christensen construes these as *S. pusillum* var. *angustissimum* (Copel.) C. Chr. *S. juncifolium* is positively not *S. angustissimum*.

3. TAENITIS SIMPLICIVENIA Cesati

Taenitis simplicivenia CESATI, Rend. Acad. Napoli 16 (1877) 30.

Christensen did not transfer this specific name, regarding it as a synonym of *S. pusillum*. He says, page 27, "*Taenitis simplicivenia* and *Monogramma intermedia* Cop.... are very nearly identical." As he, and nobody else, has seen both of these, I accept his statement, and identify as this species.

King 371, from Papua.

Range in doubt, since I do not believe my *M. intermedia* is *S. pusillum*.

3. XIPHOPTERIS Kaufuss

Key to the species

Sporangia on entire apical portion of fronds..... 1. *X. antipodalis*
Sori on lateral segments or pinnae.

Not glandular-pubescent.

Pinnatifid (not cut to the rachis).

Subcoriaceous or papyraceous.

Lamina glabrescent 2. *X. subpinnatifida*

Lamina hairy.

Fertile lobes quadrangular 3. *P. pumilum*

Lobes roundish or triangular 4. *P. sepikense*

Coriaceous 5. *X. govidjoense*

Pinnate.

Fronds up to 4 cm long 6. *P. musbravianum*

Fronds over 10 cm long.

Fronds glabrous 7. *X. conjunctisorum*

Fronds pilose 8. *P. Pullei*

Glandular-pubescent 9. *X. glanduloso-pilosum*

1. XIPHOPTERIS ANTIPODALIS Copel.

Plate 1a

X. antipodalis COPEL., U. C. Publ. Bot. 18 (1942) 224.

Rhizomate breve, erecto, paleis ferrugineis lanceolatis ca. 2 mm longis, apice breviter setuliformibus vestito; stipitibus fasciculatis, 5 mm longis, frondibusque setis castaneis 1 mm longis sparsis; fronde 10 cm longa, 2-3 mm lata, apice caudata, deorsum sterile pinnata, pinnis 1 mm longis vix 0.3 mm latis rigidis monophlebiis, rhachi inconspicue decurrenti-alata, sur-nis hujus partis frondis furcatis; soris costam secus confluentium subito fertile haud pinnata, lateribus deflexis dentatis, venis hujus partis frondis furcatis; soris costam secus confluenti-continuis, sporangiis nudis, cellulis annuli ca. 12.

DUTCH NEW GUINEA: 9 km. N. E. of Lake Habbema, alt. 2,800 m, Brass 10788, "tufted on mossy trunks of trees, uncommon."

2. XIPHOPTERIS SUBPINNATIFIDA (Blume) Copel.

X. subpinnatifida (Blume) COPEL., Genera (1947) 215.

Polypodium subpinnatifidum BLUME, Enum. (1828) 129.

Not previously reported from New Guinea, but I so determine two specimens sent by Mrs. Clemens from Mt. Sarawaket, alt. 8,000 to 11,000 feet.

To Luzon (Philippines), Malacca, Java.

3. POLYPODIUM PUMILUM Brause

P. pumilum BRAUSE, Engl. Jahrb. 49 (1912) 38, fig. 2 F.

Finisterre Mts., alt. 1,250 m, *Schlechter 19112*, sole collection.

4. POLYPODIUM SEPIKENSE Brause

P. sepikense Brause, Engl. Jahrb. 56 (1920) 182.

Sepik region, alt. 400 m, *Ledermann 7602*, sole collection.

5. XIPHOPTERIS GOVIDJOAENSIS (Brause) Copel.

X. govidjoensis (Brause) COPEL., Genera (1947) 215.

Polypodium govidjoense BRAUSE, Engl. Jahrb. 49 (1912) 41, fig. 2 K.

GERMAN NEW GUINEA, alt. 1,200 m, *Schlechter 19747*; *Clemens 12296*.

Endemic.

6. POLYPODIUM MUSGRAVIANUM Baker

P. musgravianum BAKER, Journ. Bot. 23 (1890) 108.

Mt. Musgrave, *MacGregor*, sole collection.

7. XIPHOPTERIS CONJUNCTISORUM (Baker) Copel., comb. nov.

Polypodium conjunctisorum, Annals Bot. 8 (1894) 129.

Mt. Suckling, *MacGregor*; *Amieng*, Morobe, alt. 5,000 to 6,000 feet, *Clemens 12032, 12251*.

In the description of *P. pseudo-spirale* v.A.v.R., Bull. Jard. Buit. II No. 1 (1911) 29, I find nothing against the author's suggestion that it may be *P. conjunctisorum*. Christensen and van Alderwerelt agreed in reducing to it *P. roemerianum* Ros., Nova Guinea 8 (1912) 725, which is described as having dark setae on its rachis.

8. POLYPODIUM PULLEI Alston

P. Pullei ALSTON, Jour. Bot. 78 (1940) 229.

DUTCH NEW GUINEA, Bijenhorfbivak, alt. 1,800 m, *Pulle 765*. Known by a single collection.

Species nos. 3, 4, 6, and 8 are unknown to me, and I have no opinion as to their distinctness. The key indicates the supposed differences.

9. XIPHOPTERIS GLANDULOSO-PILOSA (Brause) Copel.

X. glanduloso-pilosa (Brause) COPEL., Genera (1947) 215.

Polypodium glanduloso-pilosum BRAUSE, Engl. Jahrb. 56 (1920) 181.

GERMAN NEW GUINEA, *Ledermann* 8492, type; *Schlechter* 14469; Central Division, *Brass* 4586,—see Christensen, *Brittonia* 2 (1937) 307; *Clemens s. n.*; DUTCH NEW GUINEA, *Brass* 12606, 12689, alt. 2,150 m.

Endemic.

Brass 12606 is a very small plant, even smaller than the described type. *No.* 4686 is larger, with single acroscopic teeth on the larger segments. *No.* 12589 has fronds 15 cm long, with longer narrow segments hardly connected along the rachis, sometimes with two sub-segments. The pubescence of all is identical; I have little doubt that they represent one species, although *Nos.* 12606 and 12689 differ widely in appearance.

4. CALYMMODON Presl

Key to the species

Dark binate bristles present, veins forked.

Sterile lamina crenate-dentate 1. *C. grammitidiphyllum*

Sterile lamina practically pinnate 2. *C. kaniensis*

Dark solitary hairs present 3. *C. conduplicatus*

Hairs pale, tawny or none.

Fertile segments or pinnae fully adnate.

Fronds 3–6 mm wide 4. *C. cucullatus*

Fertile pinnae contracted toward rachis.

Fronds under 2 mm wide 5. *C. pergracillimus*

Fertile pinnae partly adnate or sessile.

Sterile pinnae obliquely deltoid 6. *C. atrichus*

Sterile pinnae oblong.

Fronds thin.

Frond 2–4 mm wide.

Frond lax, over 10 mm long..... 7. *C. ramifer*

Frond up to 3 mm long 8. *C. congestus*

Frond 7 to 10 mm wide 9. *C. mnioides*

Frond thick but brittle 10. *C. fragilis*

Fertile pinnae narrowly stalked 11. *C. clavifer*

1. CALYMMODON GRAMMITIFIPHYLLUS Copel.

Plate 1b.

C. grammitifiphyllus COPEL., U. C. Publ. Bot. 18 (1942) 224.

Caudice erecto, paleis atrocastaneis linearibus 5 mm longis apicibus setoso-protractis vestito; frondibus fasciculatis, sessilibus, usque ad 30 cm longis, 4–8 mm latis, deorsum subattenuatis, basi imo integris alibi crenato-dentatis, supra medium fertilibus dentibus soriferis plerisque majoribus oblongis, setulis

atropurpureis fasciculatis minutis plus minus deeiduis sparsis, carnosis; costa immersa, venis occultis, angulo acuto divergentibus, furcatis; lobis fertilibus more generis conduplicatis, venula in lobo simplice, sporangiis nudis.

DUTCH NEW GUINEA; 2 km. SW. of Bernhard Camp, Idenburg River, alt. 750 m, *Brass* 13443; "Rain-forest; in moss on branches of tall trees."

Vegetatively, this is a *Grammitis*, but the conduplicate fertile lobes demand its inclusion in *Calymmodon*.

2. CALYMMODON KANIENSIS (Brause) Copel.

C. kaniensis (Brause) COPEL., *Genera* (1947) 216.

Polypodium kaniense BRAUSE, *Engl. Jahrb.* 49 (1912) 40, fig. 2 H.

Schlechter 17247, isotype in Herb. Univ. Calif.; *Brass* 13789, 12828, 6 km SW. of Bernhard Camp, Idenburg River, alt. 1,200 m.

Requiring amendment of my generic description, *Philip. Jour. Sci.* 34 (1927) 259, the veins of both sterile and fertile pinnae are likely to be forked. This raises no question as to its being a *Calymmodon*, to which affinity Brause correctly assigned it. Construing *Calymmodon* as a derivative of *Grammitis* or *Xiphopteris*, the fertile veins of which are almost always forked, this peculiarity may mark the species as relatively primitive in the genus. The pubescence is equally novel in the genus, though now known in the preceding species also. Brause says: "Foliis . . . juventute supra margineque pilis brunneis e basi furcatis armata." Some setae are solitary, more are binate, some are as many as four in a cluster, a few are forked above the base. Rather dark binate hairs are not rare in *Grammitis*.

Polypodium sclerophyllum v.A.v.R., *Nova Guinea* 14 (1924) 45. Mamberamo River, alt. 210 m, *Lam* 827, is described as having deeply pinnatifid fronds 2.5 to 5.0 cm long, bearing solitary and fascicled castaneous setulae. As some of the segments are emarginate, it may be presumed that some of the veins are forked. It must be a diminutive *C. kaniensis* or a closely related dwarf species.

3. CALYMMODON CONDUPLICATUS (Brause) Copel.

C. conduplicatus (Brause) COPEL., *Philip. Jour. Sci.* 34 (1927) 268.

Polypodium conduplicatum BRAUSE, *Engl. Jahrb.* 49 (1912) 41, fig. 2 J.

GERMAN NEW GUINEA, Bismarck Mts.; Morobe, *Clemens* 11941 *partim*.

This is a dwarf, but bears peculiar hairs which bar its identification as any known species of more normal size.

4. CALYMMODON CUCULLATUS (N. & B.) Presl

C. cucullatus (N. & B.) PRESL, Tent. (1836) 204.

Polypodium cucullatum N. & B., Nova Acta 11 (1823) 121, pl. 12, fig. 3.

Lake Habbema, alt. 3,225 m, Brass 9374; alt. 2,800 m, Brass 10789; Morobe, Clemens 11941 partim.

Malaya; to Luzon.

C. hygrosopicus Copel., Philip. Jour. Sci. 34 (1927) 265, pl. 5, now seems hardly distinguishable from *C. cucullatus*.

5. CALYMMODON PERGRACILLIMUS (v.A.v.R.) Copel.

C. pergracillimus (v.A.v.R.) COPEL., Philip. Jour. Sci. 34 (1927) 263, pl. 1.

POLYPODIUM PERGRACILLIMUM v.A.v.R.

P. pergracillimum v.A.v.R., Bull. Jard. Buit. II No. XX (1915) 23.

This has never been adequately described from authentic specimens. It was based on *v. Roemer* 1220 and 1342, from the Hellwig Mountains and Wilhelmina-Top. With these, I have identified a collection by Boden-Kloss from Camp XIII of the Wollaston Expedition, and it is by this that I know the species, if at all. It is characterized by extreme slenderness, and by the reduction of the fertile "pinnae" to minute, obliquely deltoid teeth. It is near the slender form of *C. cucullatus*, but well beyond the range of variation credited to that species.

I now rename or describe three additional species, all from one of the original localities of *C. pergracillimus*, and all, however different in appearance, its near relatives. Even knowing the variability of *C. cucullatus*, I do not recognize any of these as probably identical with *C. pergracillimus*; but there may be plasticity here beyond my understanding. *C. atrichus* and *C. fragilis* are very different in texture as well as in form.

6. CALYMMODON ATRICHUS Copel., nom. nov.

Polypodium pendens C. Chr., Brittonia 2 (1937) 306, non Ros.

Brass 5253 (type) 4484, cited by Christensen; 11865, Idenburg River region, alt. 1,800 m. Exceedingly like *C. kaniensis* in gross appearance, distinguished by the absence of hairs and the uniformly unforked veins; correlated with the latter, the fertile pinnae are entire. The paleae of No. 11865 are dark, like those of *C. kaniensis*.

7. CALYMMODON RAMIFER Copel.

Plate 2.

C. ramifer COPEL., U. C. Publ. Bot. 13 (1942) 224.

C. paleis rhizomatis 1.5 mm longis (typi) lanceolatis, vel 4 mm longis lineari-lanceolatis, brunneis; stipite breve rhachique

filiformibus anguste alatis; fronde ca. 20 cm longa, 2–4 mm lata, pinnis sterilibus obliquis, ca. 2 mm longis, 0.7 mm latis, decurrentibus, tenuiter herbaceis, glabris, fertilibus aequilongis latioribus, carinato-conduplicatis, apud rhachin contractis, decurrenti-adnatis.

DUTCH NEW GUINEA; *Brass* and *Myer-Drees* 9943 A, type, 7 Km NE. of Wilhelmina-Top, alt. 3,720 m, in subalpine forest, fronds mostly two or three times forked, forming pendent tufts like a *Lycopodium*, stipes numerous and paleae small; No. 9616, alt. 3,560 m, likewise forked, stipes few and paleae large; No. 10307, alt. 3,800 m, fronds not forked.

8. *CALYMMODON CONGESTUS* Copel., sp. nov.

C. minimus; paleis rhizomatis 1–1.5 mm longis castaneis; frondibus confertissimis, usque ad 3 cm longis, 2–3 mm latis, tenuiter herbaceis, glabris, rhachi deorsum vix alata; segmentis fertilibus late ovatis, contiguis vel subimbricatis, ad rhachin anguste decurrentibus, sterilibus haud remotis, ellipticis, ca. 0.5 mm latis.

Rawlinson Range, alt. 21,000 feet. *Clemense* s. n., anno 1941.

9. *CALYMMODON FRAGILIS* Copel.

Plate 3.

C. fragilis COPEL., U. C. Publ. Bot. 18 (1942) 224.

C. paleis rhizomatis 1.5–2.0 mm longis, lanceolatis, fuscis; stipitibus subnullis vel usque ad 2 cm longis, dense fasciculatis; frondibus 10–25 cm longis, 4–5 mm latis, fragilibus, rhachi gracile anguste alata, pinnis paucis infimis plerisque 2 mm longis, 0.6 mm latis, saepe recurvis, carnosus, glabris; pinnis fertilibus numerosissimis, patentibus, 2 mm longis, etenim conduplicatis 1 mm latis ovatis, acutis, apud rhachin contractis, adnatis.

DUTCH NEW GUINEA; *Brass* and *Myer-Drees* 10035, type, 2 km E. of Wilhelmina-Top, alt. 3,800 m, "Commonest epiphyte in subalpine forest"; No. 9943, alt. 3,720 m.

Remarkable for its thick, fragile fronds, fertile almost to the base.

10. *CALYMMODON MNIOIDES* Copel.

C. mnioides COPEL., Philip. Jour. Sci. 34 (1927) 261, pl. 6.

Polypodium persimile C. CHR., Brittonia 2 (1937) 307, non Baker.

Kani Range, alt. 1,000 m, *Schlechter* 17200; *Brass* 4581, cited by Christensen; 11862, Idenburg River region, alt. 1,800 m. The fronds of the Brass collections run about 10 cm long, in contrast with the 2 to 3 cm ascribed to *C. mnioides*, but I find no more dependable specific differences. The type may be presumed to consist of old plants, as indicated by the dense

mass of stipe-bases, and dwarfed in senescence. Christensen's description applies to the plant in normal development, fronds up to 12 cm long. I have not seen *Brass* 4662, the type of *B. persimilis*.

11. *CALYMMODON CLAVIFER* (Hooker) Moore

C. clavifer (Hooker) MOORE, Index (1861) 219.

Polypodium clavifer HOOKER, Sp. Fil. IV (1862) 176.

Brass 10254, 11039, 11238, 18705, 13298, alt. 900 to 2,800 m; previously known by several New Guinea collections. A variable but well characterized species.

MINDANAO; BORNEO.

5. *ACROSORUS* Copeland

Acrosorus Schlechteri CHRIST, Geog. d. Farne (1910) 232.

Prosaptia Schlechteri CHRIST, Nachtr. Fl. Deut. Schutzgeb. Südsee (1905) 41, pl. I B.

Davallia Schlechteri C. CHR., Index (1905) 663.

Polypodium Schlechteri v.A.v.R., Malayan Ferns (1909) 614.

First collected by Schlechter; later, three times, by Ledermann Sepik region, alt. 850 to 1,500 m.

Endemic, with near relatives in Samoa, and westward to Malacca.

6. *CTENOPTERIS* Blume

Key to the species

Pinnæ or segments entire or crenate.

Fronds thin or soft and fleshy, hairy.

Fronds lobed or pinnatifid.

Fronds under 1 cm wide 1. *C. bolobensis*

Fronds 2.5 to 6.0 cm wide 2. *C. geluensis*

Fronds pinnate.

Pinnæ broadly linear 3. *P. pensile*

Pinnæ obliquely oblong.

Pinnæ acute 4. *C. beleensis*

Apex of pinnæ rounded 5. *C. micropaleata*

Fronds more or less coriaceous.

Sori superficial.

Paleae not described, presumably inconspicuous or none

P. politum

Paleae entire.

Fronds under 1 cm wide.

Pinnæ linear 6. *P. Macgregori*

Segments oblong or roundish 7. *C. pycnophylla*

Pinnæ more than 5 mm long.

Rigidly coriaceous, pinnæ dentate.

Deeply pinnatifid 8. *C. denticulata*

- Pinnate or nearly so.
 Pinnae decurrent.
 Pinnae oblong 9. *C. undosa*
 Pinnae lanceolate 10. *C. bolanica*
 Pinnae dilated rather than decurrent 11. *C. solida*
- Less rigid, pinnae mostly entire.
 Veinlets simple.
 Reduced basal pinnae many..... 16. *C. integripaleata*
 Reduced basal pinnae few.
 Lower pinnae abruptly reduced 13. *C. Curtisii*
 Lower pinnae gradually reduced.
 Frond at least 30 cm long... 15. *P. ctenoideum*
 Frond smaller.
 Frond caudate 14. *C. longiceps*
 Frond not caudate 12. *C. inconspicua*
- Veinlets forked.
 Segments acute 17. *C. schizophlebia*
 Segments obtuse 18. *C. Clemensiae*
- Paleae ciliate.
 Pinnae standing flat.
 Pinnae narrowly linear, acute, horizontal 24. *C. subulatipinna*
 Pinnae linear, acute, ascending 25. *C. rawlinsonensis*
 Pinnae broader, obtuse.
 Axes moderately hairy or glabrescent.
 Pinnae remote, confluent 22. *C. pendens*
 Pinnae closer, not confluent..... 19. *C. nutans*
 Pinnae contiguous, narrowly confluent.
 Stipe short, naked 20. *C. rhodocarpa*
 Stipe setose 21. *C. pubipes*
 Axes densely hairy 23. *C. whartonia*
 Pinnae folded upward back to back... 26. *C. fusca*
- Sori impressed or immersed.
 Paleae entire.
 Sori oblong, parallel to costa 27. *C. blechnoides*
 Sori round or oblique.
 Pinnae entire 28. *P. flagelliforme*
 Pinnae crenate 29. *C. repandula*
- Paleae ciliate.
 Frond 1 to 3 cm wide 30a. *P. cryptosorum*
 Frond wider.
 Sori not conspicuously oblique.
 Rim of soral pits low.
 Sori medial.
 Costa glabrescent 30. *C. celebica*
 Costa binate-bristly 31. *C. stellatosetosa*

- Sori subcostal 32. *P. rachisorum*
 Rim high, very conspicuous.
 Pinnae confluent 33. *C. Ledermanni*
 Pinnae not confluent.
 Sori round 34. *C. Brassii*
 Sori oblong 35. *C. venulosoides*
 Sori oblique to costa.
 Rim of soral pit not raised. 37. *C. Shawii*
 Rim moderately raised.
 Fronde 4 to 6 cm wide 36. *C. obliquata*
 Fronde 8 cm wide 38. *C. multicaudata*
 Rim very conspicuous 39. *C. circumvallata*
 Pinnae deeply toothed or more dissected.
 Pinnae mostly uncut on basiscopic side..... 47. *C. subsecundo-dissecta*
 Pinnae cut on both sides.
 Pinnae merely toothed.
 Fronde clustered 40. *C. congregatifolia*
 Fronde remote 41. *C. allocota*
 Pinnae pinnatifid or pinnate
 Rachis firm.
 Veins of primary pinnules simple.
 Sori basal on pinnules.
 Rachis densely red-hairy 42. *C. eximia*
 Hairs less dense and less red..... 43. *C. tenuisecta*
 Sori distal on pinnules.
 Pinnules naked 44. *C. taxodioides*
 Few long setae present 45. *C. Yoderi*
 Secondary costae pinnate 46. *C. millefolia*
 Rachis weak and flexuose.
 Secondary rachises evidently winged.
 Lamina glabrescent 48. *C. sesquipinnata*
 Lamina hairy.
 Axes moderately hairy 49. *C. bipinnatifida*
 Axes densely hairy 50. *C. polytricha*
 Secondary rachises barely winged 51. *C. bipinnata*

1. **CTENOPTERIS BOLOBENSIS** (Brause) Copel., comb. nov.

Polypodium bolobense BRAUSE, Engl. Jahrb. 49 (1912) 38, fig. 2 E.

GERMAN NEW GUINEA, near Bolobo, alt. 350 m, *Schlechter 16522*; isotype in Herb. Univ. Calif.

2. **CTENOPTERIS GELUENSIS** (Ros.) Copel., comb. nov.

Polypodium geluense Ros., Fedde's Repert 5 (1908) 374.

Gelu Mountain, alt. 1,000 m, *Werner 45*, isotype in Herb. Univ. Calif.; Sattelberg, alt. 1,600 m, *Keysser 10*; Ins. Rook, alt. 200 m, *Bamler R 26* (not typical); DUTCH NEW GUINEA, Idenburg River, alt. 850 m, *Brass 13207*.

Endemic.

3. POLYPODIUM PENSILE Ridley

P. pensile RIDLEY, Trans. Linn. Soc. Bot. II 9 (1916) 262.

Wollaston Exped., Camps IX to X, alt. 5,500 to 6,700 feet. Said to be hairy, pendulous, "of an almost fleshy nature," but near to *P. celebicum* Blume; it may be misplaced here.

4. CTENOPTERIS BELEENSIS Copel.

C. beleensis COPEL., U. C. Publ. Bot. 18 (1942) 225, *pl.*

Rhizomate erecto, breve, (paleis paucis stramineis 0.5 mm longis vestito); stipite 3 cm longo rhachique filiformibus, laminæ ubique pilis albidis fulvescentibus 1–3 mm longis dense lanosis; lamina 40 cm longa, 15 mm lata, flexile, pendente, deorsum (basin versus) attenuata, pinnata; pinnis triangulari-oblongis, 7–9 mm longis, basi 4 mm latis obliquis acroscopice dilatatis et semi-adnatis, vix decurrentibus, acutis vel obtusis, herbaceis; vena prima acroscopica interdum furcata caeteris simplicibus brevibus luce transmissa conspicuis; soris superficialibus, orbicularibus, ad venas terminalibus.

DUTCH NEW GUINEA, Bele River, alt. 2,200 m, *Brass 11041*; rare low epiphyte in tall forest. My observation as to the paleae may not be trusted, because made on a very young plant, not the source of the frond described.

5. CTENOPTERIS MICROPALEATA Copel.

C. micropaleata COPEL., Genera (1947) 219.

Polypodium rufescens BRAUSE, Engl. Jahrb. 49 (1912) 43, *non Ctenopteris rufescens* KUNZE.

Type, not seen, *Schultze 322*, from German New Guinea; Dutch New Guinea, *Brass 12623, 12639, 12834*, alt. 2,150 and 1,200 m. These *Brass* specimens agree with the description except that the fronds vary from obtuse to acute, and the pinnae are obtuse or rounded. Brause is silent as to the paleae; they exist, but only as ciliate vestiges, the suppression being like that familiar in *Grammitis* under the same conditions.

6. POLYPODIUM MACGREGORI Baker

P. Macgregori BAKER, Annals Bot. 8 (1894) 130.

ROSSEL ISLAND. Not seen and not comprehended; said to have fronds 6 to 8 inches long, 3 to 4 lines wide, and linear pinnæ, with superficial sori "utrinque costam uniseriatis," and to be near to *P. blechnoides* Hooker.

7. CTENOPTERIS PYCNOPHYLLA (C. Chr.) Copel., comb. nov.

Polypodium pycnophyllum C. CHR., Brittonia 2 (1937) 308.

Mt. Albert Edward, alt. 3,680 m, *Brass 4421*.

8. CTENOPTERIS DENTICULATA (Blume) Copel., comb. nov.

Grammitis denticulata BLUME, Flora Javae (1828) 121, pl. 50, fig. 4.

Reported from New Guinea by Brause,—*Ledermann* 11710, 12070.

JAVA; SUMATRA.

9. CTENOPTERIS UNDOSA (Baker) Copel., comb. nov.

Polypodium undosum BAKER, Jour. Bot. 28 (1890) 108.

Type from Mt. Musgrave, 1. *Macgregor*; said to be near *Polypodium Grammitidis* R. Br. Known to me by *Brass* 4254, 4255 from Mt. Albert Edward, alt. 3,680 m, det. Christensen.

10. CTENOPTERIS BOLANICA (Ros.) Copel., comb. nov.

Polypodium solidum var. *bolanica* ROS., Fedde's Repert. 12 (1913) 177.

P. bolanicum COPEL., U. C. Cont. Bot. 12 (1931) 403.

Bolan, alt. 3,490 to 3,800 m, *Keysser*; isotype in Herb. Univ. Calif.

11. CTENOPTERIS SOLIDA Kunze

C. solida KUNZE apud. Zoll., Syst. Verz. (1854) 37.

Brass 9174, 11031, 11851, 12605, alt. 2,150 to 3,225 m; known throughout New Guinea, and to Mindanao and Java.

Construing this species broadly in New Guinea, I probably include *Polypodium vernicosum* v.A.v.R., Nova Guinea 14 (1924) 48, typified by *Lam* 1797, Doorman-Top, alt. 3,200 m, which I have not seen.

The preceding five species are a natural group, to which *C. allocota* (No. 41) and some other more dissected species are closely related.

12. CTENOPTERIS INCONSPICUA (Blume) Copel., comb. nov.

Polypodium inconspicuum BLUME, Enum. (1828) 130.

Known in New Guinea only by a report by Ridley. It is a diminutive relative, possibly a diminutive form, of *C. Curtisii*, and has the far older name.

13. CTENOPTERIS CURTISII (Baker) Copel., comb. nov.

Polypodium Curtisii BAKER, Jour. Bot. 19 (1881) 367.

P. decrescen CHRIST, Ann. Jard. Bot. Buit. II 4 (1904) 35.

Reported from the Arfak Mts., 1 *Gibbs*.

LUZON; SUMATRA.

14. CTENOPTERIS LONGICEPS (Ros.) Copel., comb. nov.

Polypodium longiceps ROS., Fedde's Repert. 12 (1913) 177.

Bolan, alt. 2,400 to 3,000 m, *Keysser* II 72; isotype in Herb. Univ. Calif.

15. *POLYPODIUM CTENOIDEUM* Brause

P. ctenoideum BRAUSE, Engl. Jahrb. 56 (1920) 188.

GERMAN NEW GUINEA, alt. 2,000 to 2,500 m, *Ledermann 11709*, *12071a*, *12131a*, not seen. Paleae with "margine subintegro"; stipes articulate, glabrescent. Said to be a relative of *C. celebica*.

16. *CTENOPTERIS INTEGRIPALEATA* Copel.

Plate 4a.

C. integripaleata COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizomate brevi-repente, valido, paleis integris castaneis lanceolatis 6 mm longis et ovatis brevioribus vestito; stipitibus ca. 4 mm inter se remotis, non articulatis, infra rudimenta pinnarum 2–5 cm altis, 1.5–2.0 mm crassis, deorsum paleatis, alibi pilis castaneis fragilibus usque ad 1 mm longis inconspicuis sparsis; lamina ca. 30 cm alta, 4–5 cm lata, breviter caudata, fere ad rhachin pinnatifida, deorsum sat abrupte contracta, pinnis infimis ca. 10-paribus ad vestigia 4 mm lata minusquam 1 mm longa sensim evanescentia reductis, rhachi superne sulcata inferne terete sparse decidue puberula; pinnis subhorizontalibus, 2–3 cm longis, ca. 2.5 mm latis, spatio aequilato separatis, rectis, integris, basi anguste confluentibus, sparsissime decidue setoso-ciliatis aliter glabris, fusco-viridibus, coriaceis; venis immersis, inconspicuis, *fertilibus furcatis*; soris superficialibus, orbicularibus, costalibus, usque ad 12-paribus, sporangiis nudis.

DUTCH NEW GUINEA: 15 km. SW. of Bernhard Camp, Idenburg River, *Brass 12249* type, alt. 1,800 m; low tuft epiphyte in mossy forest; *No. 12376*, alt. 1,500 m, on a high mossy branch in the rain forest.

Near to *Polypodium ctenoideum* Brause as judged by description, but the stipes not articulate, and apparently different in minor details. Distinguished from *C. nutans* by entire paleae. Paleae on the base of the stipe are rare throughout this family, but are known, and equally rare, in *Grammitis*.

17. *CTENOPTERIS SCHIZOPHLEBIA* Copel.

C. schizophlebia COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizomate brevi-repente, paleis brunneis late lanceolatis 2 mm longis integris vestito; stipitibus approximatis, usque ad 10 cm longis, gracilibus, fuscis, setis obscurioribus 2 mm longis sparsis; lamina 15–25 cm longa, 6 cm lata, caudata, ad basin aut truncata aut abrupte et breviter angustata, pinnatifida, papyracea, ad marginem costamque immersam setis paucis ornata; segmentis e basibus 4–5 mm latis ad apices acutas

sensim angustatis, plerisque subfalcatis, integris; venis plerisque furcatis; soris inframedialibus, ad venas acroscopicas fere basalibus, superficialibus.

NEW GUINEA: Morobe: Amieng, alt. ca. 1,800 m, in montane bush. *M. S. Clemens*, May, 1941.

In aspect of frond, there is resemblance to the Bornean *Polypodiopteris proavita*, but there is no affinity.

18. CTENOPTERIS CLEMENSIAE Copel.

Plate 4b.

C. Clemensiae COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizomate repente, 2–3 mm crasso, paleis ovatis brunneis integris vestito; stipitibus approximatis, 10 cm longis, gracilibus, fuscis, setis obscurioribus 1.5 mm longis ornatis; lamina 15–20 cm longa, 5 cm lata, brevi-caudata, basi truncata vel pinna una vestigiale sustensa, pinnatifida, carnosocoriacea, costa immersa margineque decidue setosis; segmentis oblongo-linearibus, obtusis vel rotundatis, 3–4 mm latis, integris; venis furcatis; soris inframedialibus, ad venulas acroscopicas basalibus, superficialibus, sporangiis nudis.

NEW GUINEA: Morobe: Amieng, alt. ca. 1,800 m, in montane bush. *M. S. Clemens*, 1941.

Both this and the preceding species reach me in mixtures with various other ferns. They are related, but very distinct in appearance, chiefly because of the shape of the segments. Forked veinlets are most unusual in *Ctenopteris*,—are excluded, in fact, by the original definition; still, I feel sure that this is where these species belong. Affinity to *Polypodium Grammitidis*, also with forked veins and broad, entire paleae, is probable. *Polypodium flavovirens* Alston, Journal of Bot. 78 (1940) 228, seems to have forked veins, but to be distinct in several other respects; I have not seen it. *Polypodium Clemensiae* is a *Crypsinus*.

19. CTENOPTERIS NUTANS (Blume) J. Sm.

C. nutans (Blume) J. SM., Hist. Fil. (1875) 185.

Polypodium nutans BLUME.

Brass 9218, alt. 3,225 m, Lake Habbema, and 10302 A, alt. 3,800 m; typical except that the stipes bear a few longer setae among the very short ones, and are presently glabrescent.

C. nutans var. *trichocarpa* Ros., Fedde's Repert. 10 (1912) 339, Sattelberg, alt. 900 m, *Bamler S* 58, is distinguished by reddish-brown hairs in the sori,—a most remarkable peculiarity.

Mrs. Clemens has sent from Morobe "Upper Camp," alt. 8,000 to 9,000 feet, an undescribed plant near *C. nutans*, with more conspicuously hairy stipes.

20. CTENOPTERIS RHODOCARPA Copel.

C. rhodocarpa COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. gregis *C. nutantis*, rhizomate breve, 4 mm crasso, paleis fuscis linearibus plerisque 6 mm (rarius usque ad 9 mm) longis ciliatis immerso; stipitibus approximatis, 1.5–3 cm longis, fuscescentibus, mox glabrescentibus; lamina usque ad 25 cm longa, 4 cm lata, caudata, deorsum angustata, fere ad costam pinnatifida, coriacea, glabra siccitate recurva, segmentis subhorizontalibus, obtusis, integris, costam prope leviter dilatatis confluentibus, alibi 2.5 mm latis; venis simplicibus, confertis; soris inframedialibus, usque ad 17-paribus, superficialibus, primo roseis tum demum fuscescentibus, sporangiis nudis.

NEW GUINEA: Morobe: Amieng, alt. ca. 1,800 m, in montane bush. *M. S. Clemens*, March, 1941.

In aspect, between *C. nutans* and *C. pendens*, the segments being close (as in *C. nutans*), but confluent; more naked than either, and unlike both in the very close and numerous veins.

21. CTENOPTERIS PUBIPES Copel.

Plate 5a.

C. pubipes COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. rhodocarpae similis, stipitibus setis 1–2 mm longis fuscis persistentibus ornatis, etiam costa sparse pubescente distincta; paleis usque ad 11 mm longis; lamina 15 cm longa, 15–18 mm lata, profunde pinnatifida; venis ca. 7-paribus non confertis.

NEW GUINEA: Morobe: "Upper Camp," alt. ca. 2,500 m. *M. S. Clemens*, March, 1939.

This is like *C. rhodocarpa* in the close, confluent segments.

Polypodium abebaion v.A.v.R., Nova Guinea 14 (1924) 45, is described from a monstrosity, *Lam 1508*, Doorman-Top, alt. 1,420 m, with segments very irregular in length. It has pale, entire paleae, pubescent stipes, fronds pinnatifid to a broad wing, coriaceous, entire segments, glabrous except for marginal setulae, and practically superficial sori. I have not seen it, and cannot associate it, by description, with any species with normal fronds.

22. CTENOPTERIS PENDENS (Ros.) Copel., comb. nov.

Polypodium pendens Ros., Fedde's Repert. 12 (1913) 177.

Bolan, alt. 2,400 to 3,000 m. *Keysser B 86*, isotype in Herb. Univ. Calif.; Dutch New Guinea, *Brass 9300, 9301, 9465, 9467, 9469, 9856, 11070, 11431*, alt. 2,200 to 3,560 m. The

variability explains the number of collections. Nos. 11070 and 11431 have the axes almost glabrous; on the others, these are more hairy than on our isotype. No. 9469, in full fruit, has fronds only 15 cm long.

23. *CTENOPTERIS WHARTONIANA* (C. Chr.) Copel., comb. nov.

Polypodium whartonianum C. CHR., Brittonia 2 (1937) 309.

Brass 9468, 9470, *Brass* and *Myer-Drees* 9764, 9895, alt. 3,225 to 2,650 m, epiphytic in mossy and subalpine forest. The original collection is *Brass* 4631, Central Division, alt. 2,840 m.

If my identification is correct, as to which I have little doubt, the type collection was not typically developed. All of the Lake Habbema-Mt. Wilhelmina specimens are decidedly more hairy than the original, rather more coriaceous and elastic-curving, and with the veins more conspicuous on the upper surface. These are differences of degree only, the original being described as "dense hirtis." The veins, described as indistinct, are really quite manifest on the New York isotype, but not conspicuous as in the four new collections. The hairs, seen in mass by light reflected at a broad angle, are a remarkably fine cinnamon-red.

24. *CTENOPTERIS SUBULATIPINNA* (v.A.v.R.) Copel., comb. nov.

Polypodium subulatipinnum v.A.v.R., Nova Guinea 14 (1924) 46.

Brass 11034, Bele River, alt. 2,200 m, occasional on mossy trunks; 11850, Lake Habbema, alt. 3,225 m. The type is *Lam* 1781, foot of Doorman Summit, alt. 3,200 m. I have not seen this, and, not being quite certain of the identification, will describe *Brass*' plants:

Rhizomate brevi-repente, 4 mm crasso, paleis ciliatis fragilibus deciduis vestito; stipitibus approximatis, articulatis, 8-12 cm longis, ca. 1 mm crassis, fuscis, rhachibus minute velutinis setulis castaneis plerisque 0.2 mm longis paucis longioribus; fronde ca. 30 cm longa, 5-8 cm lata, pinnata, rhachi inter pinnae haud alata; pinnis remotis, usque ad 4.5 cm longis, 2 mm latis, plerisque curvis, basi ad rhachin sursum currentibus, coriaceis, superne praecipue ad costas setulis minutis plerisque binatis sparse donatis; soris superficialibus, sporangiis ad latera setulis brevibus atrocastaneis dense armatis.

The most remarkable characteristic of the species is the setulose sporangia, which are as rare in *Ctenopteris* as they are common in New Guinea *Grammitis*. The one-sided dilation of the pinnae is very conspicuous in *Brass*' specimens.

25. CTENOPTERIS RAWLINSONENSIS Copel.

C. rawlinsonensis COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. rhizomate breve, 3 mm crasso, paleis fuscis linearibus 5 mm longis vestito; stipitibus 10 cm longis 1 mm crassis, fuscis, setis sparsis praeditis mox glabratis, lamina 60 cm longa 6 cm lata, pinnata, rhachi pilis cinnamomeis 1.5 mm longis subsparsis vestita; pinnis erecto-patentibus, remotis, inferioribus sterilibus 4 cm longis 1.5 mm latis, infimis paucis paullo minoribus, medialibus usque ad 4.5 cm longis 3.5 mm latis, longe acuminatis, plerisque falcatis, integris, basi decurrentibus, subcoriaceis, glabris, venis immersis erecto-patentibus, simplicibus; soris supramedialibus superficialibus, receptaculo vix elongato, sporangiis nudis.

NEW GUINEA, Rawlinson Range, alt. 2,000 to 3,600 m. *Mary Strong Clemens 41953*.

Probably near *C. subulatipinna* (v.A.v.R.) Copel., but distinguished from *Brass 11034*, which I regard as that species, by erecto-patent pinnae with strongly decurrent bases not dilated on the upper side, as well as by naked sporangia; near also to *C. pendens* (Ros.) Copel., which likewise has the bases of the pinnae dilated on both sides.

The pinnae of the lower part of the frond are not connected; in the upper part, they are still remote, but connected by a narrow decurrent wing.

26. CTENOPTERIS FUSCA Copel.

Plate 5b.

C. fusca COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizomate valido, brevi-repente, paleis olivaceo-fuscis lanceolatis 5 mm longis ciliatis immerso; stipitibus approximatis, gracilibus, 4–5 cm longis, 0.5–0.8 mm crassis, atrocastaneis, minute pubescentibus, lamina ca. 10 cm longa, deorsum elongato-attenuata, supra basin conspicue arcuatim recurva, pinnata, rhachi castanea, minute sparse pilulosa, pinnis medialibus ca. 7 mm longis, supra basin vix 2 mm latis, apud rhachin paullo contractis, adnatis, paullo deflexis, basi abrupte sursum flexis dorso ad dorsum applicatis, integris vel obscure crenatis, glabris, olivaceo-fuscis, rigide coriaceis, costis venisque immersis occultis; soris superficialibus, orbicularibus, ca. 3-paribus, denique confluentibus, rhachin versus carentibus, sporangiis nudis.

DUTCH NEW GUINEA: 7 km. NE. of Wilhelmina-Top, alt. 3,560 m, *Brass and Myer-Drees 9897*; "common tuft epiphyte in moss of subalpine forest; fronds sharply reflexed."

Related to *C. nutans*, but distinct and even unique in appearance. The bending downward of the rachis may bring the

distal part of the frond directly downward, or may even carry it past the stipe, but is still less striking than the uniform upward-bending of the pinnae, bringing their dorsal surfaces flatly into imbricate contact.

27. CTENOPTERIS BLECHNOIDES (Grev.) Wagner and Grether

C. blechnoides (Grev.) WAGNER and GREETHER, U. C. Publ. Bot. 23 (1943) 61.

Grammitis blechnoides GREV., Ann. Mag. Nat. Hist. II 1 (1848) 328. pl. 12.

Brass 13444, 13730, 14129, Idenburg River, alt. 75 to 750 m. Already well known in New Guinea.

Tahiti across Malaya.

Mrs. Clemens has sent from Mt. Sarawaket, alt. 11,000 feet, an undescribed plant altogether like *C. blechnoides* in aspect, but with ciliate paleae and superficial sori.

28. POLYPODIUM FLAGELLIFORME Brause

P. flagelliforme BRAUSE, Engl. Jahrb. 56 (1920) 187.

Sepik region, alt. 1,000 m; *Ledermann* 10075, 10165a. Not seen.

29. CTENOPTERIS REPANDULA Kunze apud Zoll.

C. repandula KUNZE apud ZOLL., Syst. Verz. (1854) 37.

Bele River, alt. 2,200 m, *Brass* 11548; previously reported by Ridley.

CEYLON. This is an improbable range, particularly in this genus.

POLYPODIUM PEDICULATUM Baker

P. pediculatum BAKER, Syn. Fil. (1868) 455.

Brause reports *Ledermann* 10028 and 10334 as this species. It was described from Borneo, and, in spite of its illustration, as *P. lobbianum* Hooker, Sp. Fil. IV, Pl. 278 B, I am not sure what it is.

30. CTENOPTERIS CELEBICA (Blume) Copel.

C. celebica (Blume) COPEL., Genera (1947) 219.

Polypodium celebicum BLUME, Enum. (1828) 127; Flora Javae II 179, pl. 84 B.

Brass 12128, 12248, 12298, 12663, alt. 1,800 to 2,150 m; reported from the Sepik region, with a variety *aurita*, by Brause.

MALAYA; PHILIPPINES.

Polypodium cryptosorum C. Chr., Index (1906) 520, is reported from New Guinea, but unknown to me there. It is apparently related to *C. celebica* and to *C. geluensis*.

31. CTENOPTERIS STELLATOSETOSA Copel.

C. stellatsetosa COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizoma deest. Stipite 4 cm longo, 1.5 mm crasso, terete, setis castaneis patentibus 1.5 mm longis dense vestito; lamina 45 cm longa, utrinque sensim attenuata, subpinnata, rhachi superne dense setulosa, inferne setulis atrocastaneis 0.5–1.0 mm longis conspicue fasciculatis sparsa; pinnis infimis 1.5 mm longis, 7 mm latis, sequentibus semiorbicularibus 4 mm longis, medialibus usque ad 38 mm longis, 4.5 mm latis, recte patentibus, apice rotundatis, basi vix dilatatis contiguas vix confluentibus, integris, coriaceis, minute setuloso-ciliatis, superne glabris, inferne ad et costam secus immersam setulis minutis plerisque binatis ornatis, venis immersis simplicibus; soris supramedialibus, usque ad 17-paribus, receptaculo levissime impresso setulis deciduis circumdatis, sporangiis parvis, nudis.

NEW GUINEA, Morobe, Matap, alt. ca. 1,700 m. *Mary Strong Clemens* 40959.

An immediate relative of *C. celebica* distinguished by the conspicuously fascicled setae; also by broader pinnae and less impressed sori.

32. POLYPODIUM RACHISORUM Christ

P. rachisorum CHRIST, Nova Guinea 8 (1909) 154.

Noord River, *Versteeg* 1555; also, without locality, *Ledermann* 7489; not seen and possibly misplaced here.

33. CTENOPTERIS LEDERMANNI (Brause) Copel., comb. nov.

Davallia Ledermanni BRAUSE, Engler's Jahrb. 56 (1920) 123.

Polypodium subhamato-pilosum v.A.v.R., Bull. Jard. Buit. III No. 5 (1922) 220.

Sepik region, alt. 2,070 m, type; Mt. Tafa, alt. 2,400 m, *Brass* 5026, det. Christensen.

34. CTENOPTERIS BRASSII Copel.

Plate 6a.

C. Brassii COPEL., U. C. Publ. Bot. 18 (1942) 225.

Rhizomate brevi- repente, paleis pallide olivaceis 7–10 mm longis linearibus ciliatis vestito; stipite 3–12 cm longo, fusco, setis cinnamomeis 1.5–2.0 mm longis vestito; lamina 30 (vel, teste lectore, usque ad 150) cm longa, 3–4 cm lata, utrinque sensim angustata, pinnata, rhachi utraque facie setis atrocastaneis 1.5 mm longis obsita; pinnis ca. 2 cm longis, 5 mm latis, plerisque falcatis, basi basiscopice paullo dilatatis acroscopice subauriculato-adnatis, rigide coriaceis, sparsissime ciliatis, costa venisque immersis inconspicuis; soris marginalibus vel submarginalibus, vallis altis interne et ad ora setosis circumdatis.

DUTCH NEW GUINEA, Lake Habbema, alt. 3,225 m, *Brass* 9302, type "Pendent epiphyte common in forests; fronds to 1.5 m long"; No. 11000, alt. 3,000 m, "common low epiphyte in stunted mossy forest," the frond sent for identification 90 cm long, 3 cm wide.

Related to *C. Ledermannii*, but clearly distinguished by the non-confluent pinnae with oblique bases, perhaps also by the rather copious hairs in the craters.

To this species belongs questionably *Brass* 9463, with fronds 30 cm long by 15 mm wide, the nether surface fairly persistently setulose; it may be regarded as distinct, when the range of variation within the species is better understood.

35. CTENOPTERIS VENULOSOIDES Copel.

Plate 6b.

C. venulosoides COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. rhizomate 4 mm crasso lignoso, crateris elevatis frondibus abscissis relictis ornato, paleis perpaucis 1.5 mm longis atrofusca integris sparso; stipitibus 15 cm longis, fuscis, fere glabratis, lamina 45 cm longa, 4-5 cm lata, pinnata, rhachi nigra setis brevibus nigris praecipue inferne dense obsita, pinnis recte patentibus, 1.5 mm latis, linearibus, subacutis, basibus modo dilatatis fere contiguis, rigide papyraceis, sparsissime ciliatis aliter glabris, venis facie superiore conspicuis simplicibus, angulo acuto distantibus; soris impressis, e facie superiore laminae more *C. contiguae*, conspicuis, receptaculo elliptico, costae fere parallelo, leviter circumvallato, haud ciliato.

NEW GUINEA, Morobe, Rawlinson Range, alt. 2,000 to 3,600 m. *Mary Strong Clemens* 41394.

Distinguished from *C. venulosa* Kunze by long stipe, denser, shorter and darker hairs on the rachis, position of sori, and absence of hairs on or within the rim of the soral depression. *Polypodium flagelliforme* Brause is known to me by description only; it is described as with short stipe, densely hairy with "pilis porphyreis," and round, subimmersed sori.

I have three fragments of the rhizome of *C. venulosoides*, bearing very few and old paleae. In the absence of the tip of the rhizome, the paleae are only doubtfully known.

36. CTENOPTERIS OBLIQUATA (Blume) Copel., comb. nov.

Polypodium obliquatum BLUME, Enum. (1828) 128; Flora Javae 181, pl. 85 B.

C. rufescens KUNZE, Bot. Zeit. 4 (1846) 425.

Two varieties have been described from New Guinea: var. *novoguineensis* ROS., Fedde's Repert. 5 (1908) 374.

Gelu, alt. 1,000 m; *Wagner 45a*, isotype in Herb. Univ. Calif. This is a large form, reasonably treated as a variety by those who use the term.

Var. *multijuga* Ros., Fedde's Repert. 12 (1913) 178, from Mt. Bolan, alt. 2,400 to 3,000 m, *Keysser B 45*, isotype in Herb. Univ. Calif. This is really not very near to *C. obliquata*, but may not be distinct from *C. venulosa*.

37. CTENOPTERIS SHAWII Copel., comb. nov.

Plate 7.

Polypodium Shawii COPEL., Philip. Jour. Sci. § C 9 (1914) 6.

Papua: Taupota, *King 424*. Known by the one collection.

38. CTENOPTERIS MULTICAUDATA Copel., comb. nov.

Polypodium multicaudatum COPEL., Philip. Jour. Sci. 1 Suppl. (1906) 160, pl. 19.

Brass 13653, Idenburg River, alt. 700 m, occasional epiphyte in rain forest. The pinnae are less attenuate than on the type, but it is within the range of variation in Mindanao. It is a much coarser plant than *C. obliquata* v. *novoguineensis*, the pinnae more remote and rather irregularly placed, as is true of all Mindanao specimens.

39. CTENOPTERIS CIRCUMVALLATA (Ros.) Copel., comb. nov.

Polypodium circumvallatum Ros., Fedde's Repert 5 (1908) 374.

Bolan, alt. 3,400 to 3,800 m; *Keysser II 39*; isotype in Herb. Univ. Calif.

The preceding five species are a group intimately related to *Prosaptia*, some have been included in that genus, and all might be; but it is impracticable to draw a line between them and the many species preceding them.

40. CTENOPTERIS CONGREGATIFOLIA (v.A.v.R.) Copel., comb. nov.

Polypodium congregatifolium v.A.v.R., Nova Guinea 14 (1924) 47.

Doorman-Top, alt. 1,420 m, *Lam 1544*, isotype in Herb. Univ. Calif; Bele River, alt. 2,200 m, *Brass 11271*.

41. CTENOPTERIS ALLOCOTA (v.A.v.R.) Copel., comb. nov.

Polypodium allocotum v.A.v.R., Nova Guinea 14 (1924) 47.

Doorman-Top, alt. 3,200 m, *Lam 1800*; Lake Habbema, alt. 3,225 m, *Brass 9466*.

42. CTENOPTERIS EXIMIA Copel.

Polypodium eximium BRAUSE, Engl. Jahrb. 56 (1920) 186, non Kunze.

Sepik region, alt. ca. 1,500 m, *Ledermann 12666a*, type, not seen; Idenburg River, alt. 1,200 to 1,800 m, *Brass 12818, 12373*.

This species is without a name valid for transfer from *Polypodium*, and I give it, without transfer, the name *eximia*, valid in *Ctenopteris*.

43. **CTENOPTERIS TENUISECTA** (Blume) J. Smith

C. tenuisecta (Blume) J. SMITH, Hist. Fil. (1875) 185.

Polypodium tenuisectum BLUME, Enum. (1828) 134.

Several collections in German New Guinea; Doorman-Top, alt. 2,460 m, *Lam* 1938. The variety *paucisetosa* Ros., Fedde's Repert. 5 (1908) 42, from Gelu, *Werner* 29, is the form common in the Philippines, not really distinguishable.

The type was from Java.

44. **CTENOPTERIS TAXODIODES** (Baker) Copel., comb. nov.

Polypodium taxodioides BAKER, Jour. Bot. II 8 (1879) 42.

Brass 11597, 10276, Lake Habbema region, alt. 2,200 to 2,800 m.

Rosenstock's variety *ericoides*, from Bolan, alt. 2,400 to 3,000 m, *Keysser* II 77, is indistinguishable.

45. **CTENOPTERIS YODERI** Copel.

C. Yoderi COPEL., Genera (1947) 219.

Polypodium Yoderi COPEL., Philip. Jour. Sci. 1 Suppl. (1906) 161.

P. tamiense BRAUSE, Engl. Jahrb. 49 (1912) 43, *teste* Brause.

Rosenstock's variety *setulosa*, Fedde's Repert. 12 (1913) 179, from Bolan, alt. 2,400 to 3,000 m, *Keysser* II 77a, is not distinguishable. The collection of mixtures in this group is worthy of attention.

46. **CTENOPTERIS MILLEFOLIA** (Blume) Copel.

C. millefolia (Blume) COPEL., Genera (1947) 219.

Polypodium millefolium BLUME, Enum. (1828) 134; Flora Javae II 190, pl. 88 A.

Brass 10277, 12349, 13205, alt. 850 to 2,800 m; Sattelberg, *Keysser* 244. As I construe it, this species is variable in several respects, and I am unable to distinguish:

Polypodium Alderwereltii Ros., C. Chr. Index Suppl. I (1931) 58.

P. Koningsbergeri Ros., Nova Guinea 8 (1912) 726, non v.A.v.R.

P. rigidifrons v.A.v.R., Bull. Jard. Buit. II No. 20 (1915) 23.

P. Wollastonii RIDLEY, Trans. Linn. Soc. Bot. II 9 (1916) 262, which appears to differ only in having an elongate rhizome, being in that respect like *C. taxodioides* and *C. Yoderi*.

The preceding five species probably constitute Moore's Section *Thymelium* of *Polypodium*, typified by *P. tenuisectum* Blume. They are a natural group, but not very nearly related to the following species with equally dissected fronds.

47. CTENOPTERIS SUBSECUNDODISSECTA (Zoll.) Copel., comb. nov.

Polypodium subsecundodissectum ZOLL., Syst. Verz. (1854) 38, 48.

Brass 11338, Bele River, alt. 2,200 m; pinnae strongly recurved. I suppose that this is *Polypodium secundum* Ridley, Trans. Linn. Soc. Bot. II 9 (1916) 262, from the same region.

48. CTENOPTERIS SESQUIPINNATA Copel.

C. sesquipinnata COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. rhizomate breve, erecto, radicibus stipitibusque obsesso, paleis ut videtur carentibus; stipitibus fasciculatis, ca. 3 cm longis, gracilibus, pilis paucis pallidis fragilibus 1 mm longis vestitis; lamina 35 cm longa, 2 cm lata, debiliter pendente, pinnata, rhachi sparsissime decidue hirta, sursum anguste alata; pinnis erecto-patentibus, 12 mm longis, 2.5 mm latis, subacutis, oblique adnatis, inconspicue decurrentibus, firme herbaceis, pinna-tifido-serratis, pilis paucis parvis deciduis sparsis; venis brevibus, vix in dentes entrantibus; soris superficialibus, orbicularibus, costalibus, dentes non complentibus, sporangiis nudis.

DUTCH NEW GUINEA, Lake Habbema, alt. 3,225 m, *Brass* 9510, common epiphyte in closed mossy forest.

Related to *C. bipinnatifida*, but slender, symmetrical, and much less hairy.

49. CTENOPTERIS BIPINNATIFIDA (Baker) Copel., comb. nov.

Polypodium bipinnatifidum BAKER, Journ. Bot. 28 (1890) 109.

Brass and *Myer-Drees* 9903, Wilhelmina-Top, alt. 3,560 m; *Mrs. Clemens*, Mt. Sarawaket, alt. 9,000 to 11,000 feet. The type was collected by MacGregor on the Owen Stanley Range. A peculiar species, quite indefinite in size, forming pendent tufts, the fertile and sterile parts of the same frond sometimes very unlike. The variety *Forsteri* Ros., Fedde's Repert. 12 (1913) 179, is a hairy form, perhaps exceptionally so.

50. CTENOPTERIS POLYTRICHA Copel.

Plate 9.

C. polytricha COPEL., U. C. Publ. Bot. 18 (1942) 225.

C. rhizomate erecto, breve, radicibus et stipitibus occulto, paleis vestigialibus; stipitibus ca. 5 cm longis, gracilibus, frondibusque ubique pinis albidis ferruginescentibus 2-4 mm longis densissime obsitis; fronde 40 cm longa vel longiore, 2 cm lata, pinnata, basin versus longe attenuata, rhachi sursum angustissime alata; pinnis 5-10 mm longis, 3-4 mm latis, obtusis, adnatis et inconspicue decurrentibus, pinnatifide-lobatis, membranaceo-herbaceis; lobis, resp. dentibus, ca. 1 mm longis latisque, rotundatis, momophlebiis et monosoris; soro superficiale, orbiculare, lobum complente, sporangiis nudis.

DUTCH NEW GUINEA: 9 km NE. of Lake Habbema, alt. 2,860 m, *Brass* 10518, rare tuft epiphyte in mossy forest.

Related to *C. bipinnatifida* and *C. beleensis*.

51. CTENOPTERIS BIPINNATA Copel.

Plate 10.

C. bipinnata COPEL., U. C. Publ. Bot. 48 (1942) 225.

C. rhizomate breve, paleis paucis fuscis vix 1 mm longis basibus pilosis stipitum occultis vestito; stipite breve rhachique flexuosa gracillimis, 0.3–0.4 mm crassis, pilis pallide fulvis 1.5–2.0 mm longis debilibus sursum decrescentibus et caducis vestitis; lamina 30–60 cm longa, lineare, bipinnata; pinnis 2–3 cm longis, angulo acuto pendentibus, rhachibus filiformibus vix alatis; pinnulis remotis, adnatis, plerisque obovatis, ca. 1 mm longis, glabris, venula simplice, soro parvo inframediale.

DUTCH NEW GUINEA, Lake Habbema, alt. 3,225 m, *Brass* 9433, pendent under leaning trees in mossy forest.

An immediate relative of *C. bipinnatifida*, but much more finely divided.

7. PROSAPTIA Presl

The recognition of *Prosaptia* as a genus distinct from *Ctenopteris* is purely a matter of convenience. Its affinity to *Ctenopteris* is evident and intimate. With a different idea of convenience, or with more compelling respect for affinity, one may reasonably combine the two genera. More than elsewhere, the distinction is difficult in New Guinea, which may well be the land where *Prosaptia* became differentiated.

Key to the species

Sori marginal, approximately in the laminar plane.

Sori plural, or terminal on segments.

Sori occupying lobes or teeth.

Hairs on stipe under 0.5 mm long 1. *P. contigua*

Hairs on stipe and rachis 1–2 mm long 2. *P. Archboldii*

Margin entire or crenate.

Pinnatifid within 1 mm of costa 4. *P. Rosenstockii*

Less deeply pinnatifid 4. *P. alata*

Sorus single on acroscopic margin 7. *P. davalliacea*

Sori almost marginal in oblique pits.

Frond 5–8 mm broad 8. *P. capillipes*

Frond much wider.

Segments up to 2.5 mm broad 6. *P. Leysii*

Segments over 3 mm broad 5. *P. engleriana*

1. PROSAPTIA CONTIGUA (Forster) Presl

P. contigua (Forster) PRESL, Tent. (1836) 166.

Trichomanes contiguum FORSTER, Prod. (1786) 84.

Sattelberg, alt. 900 m, *Bamler 90*; Ins. Rook, *Bamler R 24*.

Typical *C. contigua* is pinnate to the rhachis but the pinnae are contiguous. The hairs on the stipe are very short, dense but not always persistent, almost wholly solitary, and the pinnae and their segments are conspicuously narrow.

POLYNESIA.

2. PROSAPTIA ARCHBOLDII Copel.

P. Archboldii COPEL., U. C. Publ. Bot. 18 (1942) 226.

P. contiguae affinis et similis, soris etiam dentes pinnarum complentibus, differt; fronde usque ad rhachin pinnata pinnis medio longitudine frondis non contiguis, setis stipitis 1-2 mm longis rhacheosque inferne saepe binatis vel ternatis.

DUTCH NEW GUINEA: 15 km SW. of Bernhard Camp, Idenburg River, alt. 1,200 m, *Brass 12020*, type, low tufted epiphyte in mossy forest; also *Brass 10631, 10700, 11032, 11594, 12794*, altitudes 1,200 to 2,000 m.

3. PROSAPTIA ALATA (Blume) Christ

P. alata (Blume) CHRIST, Ann. Jard. Buit. II 5 (1905) 127.

Davallia alata BLUME, Enum. (1828) 230.

GERMAN NEW GUINEA, *Bamler*; *Ros., Fil. Novog. Excicc. 213*; Reported as collected by Werner also.

JAVA; SUMATRA.

Frond decurrent almost to rhizome, pinnatifid to a very broad wing, with acute sinuses.

4. PROSAPTIA ROSENSTOCKII Copel.

P. Rosenstockii COPEL., U. C. Publ. Bot. 12 (1931) 404.

Ins. Rook, alt. 240 m, *Bamler 23 R*.

5. PROSAPTIA ENGLERIANA (Brause) Copel.

P. engleriana (Brause) COPEL., U. C. Publ. Bot. 12 (1931) 404.

Davallia engleriana BRAUSE, Engl. Jahrb. 49 (1912) 37, f. 1 H.

GERMAN NEW GUINEA, Kelel, alt. 600 m; two isotype sheets in Herb. Univ. Calif.

Fronds 30 to 85 cm long, pinnae narrowly confluent.

6. PROSAPTIA LEYSII (Baker) Copel., comb. nov.

Polypodium Leysii BAKER, Jour. Bot. II 8 (1879) 66.

Prosaptia semicrypta COPEL., Philip. Jour. Sci. § C 9 (1914) 231.

Brass 4610, Central Division, Murray Pass, alt. 2,840 m, det. Christensen, *Brittonia* 2 (1937) 310.

Distinctly more coriaceous than the typical plants of Sulu, Malacca and Sumatra.

7. **PROSAPTIA DAVALLIACEA** (Mueller and Baker) Copel.

P. davalliacea (Mueller and Baker) COPEL., U. C. Publ. Bot. 12 (1931) 404.

P. davalliaceum MUELLER and BAKER, Jour. Bot. 28 (1890) 108.

P. monocarpum ROS., Fedde's Repert. 12 (1913) 178.

Wilhelmina-Top, alt. 3,400 m, *Brass* and *Myer-Drees* 9650; Mt. Sarawaket, alt. 8,000 to 11,000 feet, *Mrs. Clemens*. The type is an older New Guinea collection.

BORNEO, Mt. Kinabalu, *teste* Christensen, Gardens' Bull. 7 (1934) 303.

P. linearis, of Luzon, is similar rather than identical.

8. **PROSAPTIA CAPILLIPES** (C. Chr.) Copel., comb. nov.

Polypodium capillipes C. CHR. Brittonia 2 (1937) 310.

Central Division, Murray Pass, alt. 2,840 m, *Brass* 4731; Mt. Albert Edward, alt. 3,680 m, *Brass* 4413.

The smallest plant of its genus; nearest, but not very nearly, related to *P. davalliacea*. The soral pits are oblique, rather than perpendicular, to the plane of the lamina.

8. **LOXOGRAMME** (Blume) Presl

Botanists are not in agreement as to the proper place of this genus, Ching going so far as to make it a distinct family. All New Guinea specimens seem properly to belong in Grammitidaceæ.

Key to the species

Fronds about 5 cm wide, oblanceolate 1. *L. scolopendrina*

Fronds much narrower.

Fructification interrupted 2. *L. subselliguela*

Coenosorous continuous 3. *L. paltonioides*

1. **LOXOGRAMME SCOLOPENDRINA** (Bory) Presl

L. scolopendrina (Bory) PRESL, Tent. (1836) 215.

Grammitis scolopendrina BORY, Voy. Dup. Bot. 1 (1828) 257.

GERMAN NEW GUINEA, Finisterre Mts., *Werner* 10; *Bamler* 40a; Papua, *King* 297.

To Guadalcanal and Malacca; the type ascribed in error to New Zealand.

2. **LOXOGRAMME SUBSELLIGUEA** (Baker) Alston

L. subselliguela (Baker) ALSTON, Jour. Bot. 77 (1939) 289.

Polypodium subselliguelum BAKER, Jour. Bot. 28 (1890) 107.

L. parallela ROS., in herb.; ALSTON, l.c., non Copel.

L. major COPEL., Philip. Jour. Sci. 56 (1935) 106.

The type, a fragment from Mt. Knutsford, not seen; Mt. Sarawaket, *Clemens* s. n.; Bolan, alt. 2,400 to 2,800 m. *Keysser*

II 40, II 81; Lake Habbema region, *Brass 9221, 10254, 11240*; Idenburg River region, alt. 850 m, *Brass 13374*. More than one species may be confused here.

MINDANAO; BORNEO.

3. LOXOGRAMME PALTONIOIDES Copel.

L. paltonioides COPEL., Philip. Jour. Sci. § C 6 (1911) 87; 11 (1916) pl. 4, fig. 15.

Paltonium vittariiforme ROS., Fedde's Repert. 10 (1912) 341; C. CHR. Dansk bot. Arkiv 6 No. 3: 52, pl. 7, fig. 1, 2.

L. vittariiformis C. CHR., Brittonia 2 (1937) 315.

Papua, *King 253*, type of *L. paltonioides*; Cromwell Mts. *Bamler s. n.*, type of *Palt. vittariiforme*; Mt. Tafa, alt. 2,400 m, *Brass 5090*, teste C. Chr.; Bernhard Camp. Idenburg River, *Brass 12377, 12378, 12383*.

Endemic.

The type of *P. vittariiforme* is a single frond, and I find nothing in its description to distinguish it from *L. paltonioides*. Christensen saw it, and I follow him in the identification of all *Brass* collections; these are stouter, far larger and narrower, and do not look like the same species.

ILLUSTRATIONS

[All plates are from photographs, by V. Duran, of types in the herbarium of the author.]

- PLATE** 1a. *Xiphopteris antipodalis*
b. *Calymmodon grammitidiphyllus*
2. *Calymmodon ramifer*
3. *Calymmodon fragilis*
4a. *Ctenopteris integripaleata*
b. *Ctenopteris Clemensiae*
5a. *Ctenopteris pubipes*
b. *Ctenopteris fusca*
6a. *Ctenopteris Brassii*
b. *Ctenopteris venulosoides*
7. *Ctenopteris Shawii*
8. *Ctenopteris sesquipinnata*
9. *Ctenopteris polytricha*
10. *Ctenopteris bipinnata*



PLATE 1.



PLATE 2.



PLATE 3.



PLATE 4.

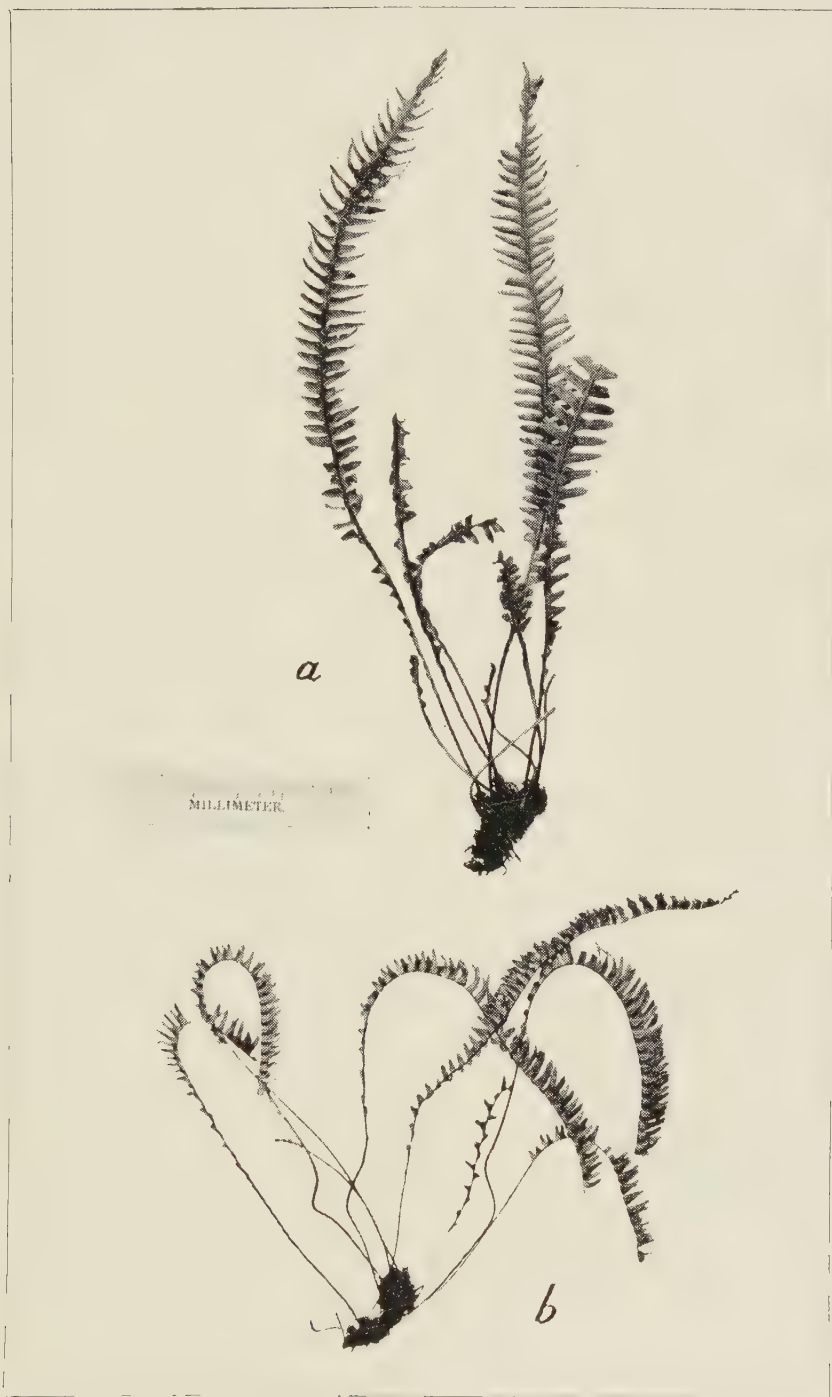


PLATE 5.

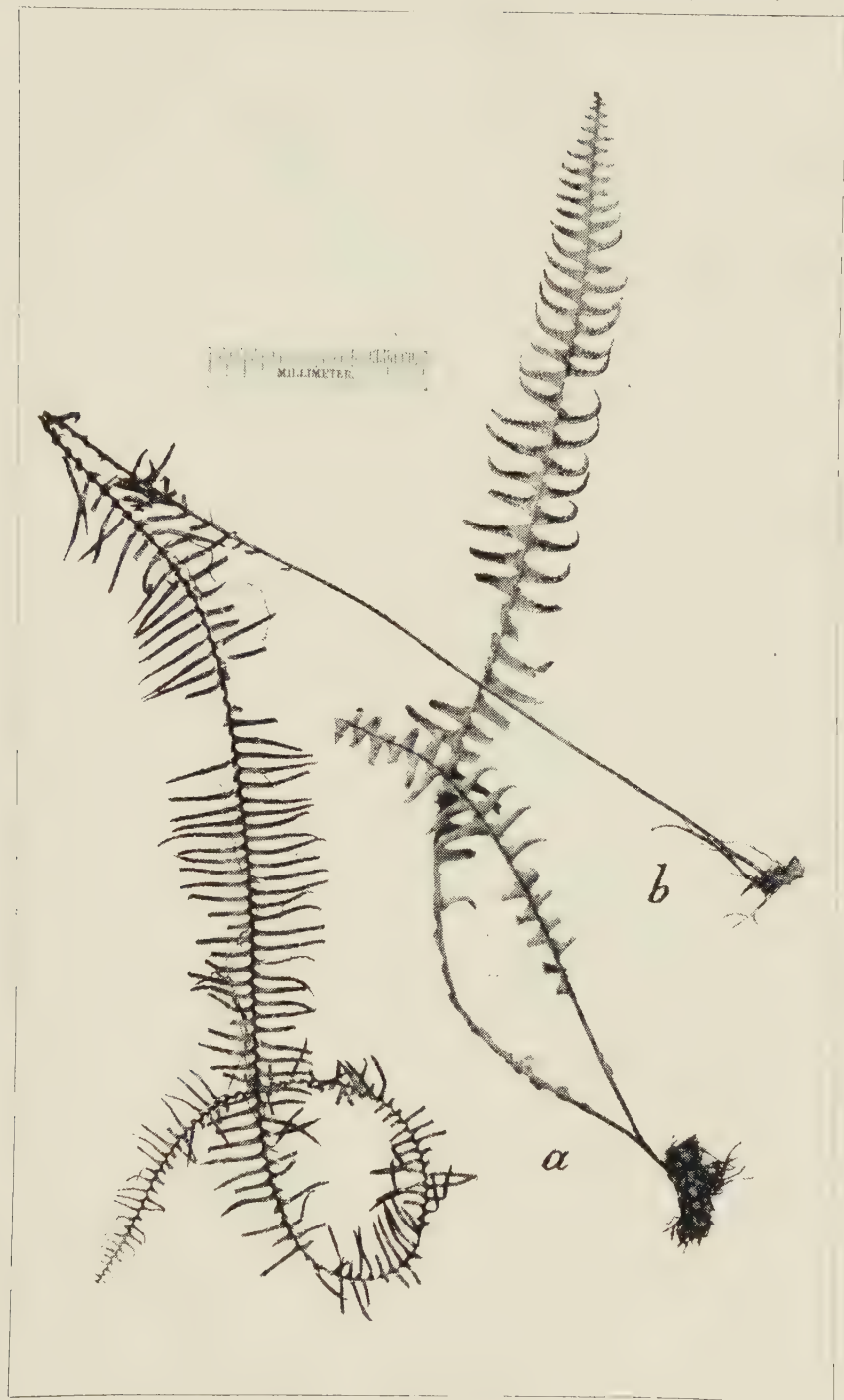


PLATE 6.



PLATE 7.



PLATE 8.



PLATE 9.



PLATE 10.

STARCH HYDROLYSIS BY NEUROSPORA *

By FLAVIANO M. YENKO and PAULINA UMALI
Of the Institute of Science and Technology, Manila

ONE TEXT FIGURE

In view of the fact that, as far as the writers are aware of, there is no report on the amylolytic properties of *Neurospora*, it was decided to undertake an investigation on this particular property of the organism as it has been found to grow on and liquefy rice producing a sweet and sirupy liquid. There is very scant mention about the *Neurospora* organism either in textbooks or in publications. Salle¹ describes the organism thus: "This genus contains only one species of common occurrence. *Monilia sitophila* is found in laboratory air and causes contaminations of cultures and media. It grows rapidly on media in loosely floccose masses and produces a pale pink to salmon pink color. The aerial hyphae contain oval-shaped conidia at their tips. The conidia increase by budding, eventually producing large, irregular masses. As the hyphae age, the individual cells break apart. Each cell is capable of producing a new plant." Smith² says: "One species, *M. sitophila* (Montagne) Saccardo, is best known as the red bread mould. From time to time outbreaks of the infection occur in bakeries but, more often, this species attacks wrapped and, particularly, sliced bread, and is noticed only after the bread has left the bakery. In an amazingly short time the bread becomes covered with a characteristic pink, loose-texture growth." According to Shear and Dodge³ it also attacks sugar cane bagasse in store, forming long pink festoons from the bales. It is commonly found as an aerial contaminant and can be a great nuisance in a culture room since it spreads with extreme rapidity on most media.

EXPERIMENTAL PROCEDURE

The percentage of moisture in the rice, corn, sweet potato and cassava as received, was determined. The starch content was determined following the direct acid hydrolysis method

* Weiss, Gruman A. Curator of American Type Culture Collection, Washington, D.C., identified the fungus as *Neurospora crassa*.

¹ Salle, A. J. Fundamental principles of bacteriology. New York and London, McGraw Hill Book Co. 2nd ed. (1943) 634 p.

² Smith, G. An introduction to industrial mycology. London, Edward Arnold and Co. 3rd ed. (1946) 271 p.

³ Shear and Dodge. Jour. Agric. Res. 34: 1019-42.

of Leach,⁴ and calculated on the dry basis. The percentages reducing sugars and sucrose were also carried out using Fehling's Volumetric Method.

TABLE 1.—Showing the percentages of moisture, starch, sucrose and reducing sugars in rice, corn, sweet potato and cassava.

Sources	Moisture	Starch	Sucrose	Reducing sugar
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Rice.....	9.43	79.93	0.00	0.00
Corn.....	10.62	75.51	0.00	0.00
Sweet potato.....	36.49	67.65	10.56	Traces
Cassava.....	54.98	74.48	00.00	0.00

Three separate cultures of *Neurospora*, isolated from various sources, like corncobs, rice, etc., were used. They are designated as X, X₁ and X₂ respectively.

One hundred grams of the dry material and 200 cc of water were placed in a 16 cm diameter dish and autoclaved at 15 lbs. for 20 minutes. The cooled sterile mass was inoculated with the spores of the corresponding organism and aseptically stirred with a sterile spatula and set aside at room temperature (28° to 30°C.).

On the second day after inoculation and every day thereafter, the percentages of reducing sugar and moisture were determined. The determinations were discontinued when the amount of reducing sugars started to decrease.

TABLE 2.—Showing percentages of reducing sugars in inoculated mass.

Number of days after inoculation	Reducing sugars											
	X				X ₁				X ₂			
	Rice	Corn	Sweet potato	Cassava	Rice	Corn	Sweet potato	Cassava	Rice	Corn	Sweet potato	Cassava
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
2	22.08	-----	27.67	17.18	13.86	-----	24.63	3.62	15.78	-----	33.31	15.96
3	34.17	34.12	39.22	26.89	21.68	9.22	33.48	4.58	33.41	27.63	45.08	32.32
4	46.08	45.53	44.43	33.85	32.64	32.02	32.98	5.38	46.81	40.78	44.80	35.58
5	54.82	53.71	43.85	39.87	36.44	40.78	-----	5.66	52.91	45.70	-----	42.44
6	61.19	48.03	-----	44.76	47.52	37.65	-----	7.07	59.17	41.18	-----	41.53
7	68.02	-----	-----	39.59	53.25	-----	-----	6.83	69.44	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9	68.87	-----	-----	-----	56.00	-----	-----	-----	68.68	-----	-----	-----
10	68.39	-----	-----	-----	53.87	-----	-----	-----	-----	-----	-----	-----

Qualitative tests for dextrose and maltose were made following the methods of Leach.⁴

On the day following the occurrence of the optimum sugar content, the percentage of dextrin was determined according to the following method: A certain weight of the sample was

⁴ Leach, A. E. Food inspection and analysis. New York, John Wiley and Sons, Inc. 4th ed. (1936) 1090 p.

taken and diluted to 250 cc. After maceration and grinding, the solution was then filtered with kaolin until the filtrate was

TABLE 3.—Showing highest percentage of starch hydrolyzed.

Source of starch	X			X ₁			X ₂		
	Starch converted to—			Starch converted to—			Starch converted to—		
	Reduc- ing sugar	Dex- trin	Total hydro- lysate	Reduc- ing sugar	Dex- trin	Total hydro- lysate	Reduc- ing sugar	Dex- trin	Total hydro- lysate
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Rice.....	77.54	6.57	84.11	63.05	9.54	72.59	78.18	6.51	84.69
Corn.....	64.02	2.91	66.93	48.60	6.98	55.58	54.46	6.06	60.52
Sweet potato.....	48.16	10.04	58.20	37.80	13.95	51.75	48.91	11.61	60.52
Cassava.....	54.09	13.83	67.92	8.54	21.66	30.20	51.28	16.39	67.67

clear. One hundred cc aliquot were taken and evaporated down to about 25 cc at 80°C. To this volume 3 volumes of 95 per cent alcohol were added and allowed to settle for 24 hours. The supernatant liquid was filtered through a tared filter paper and the dish to which most of the dextrin adhered and the filter paper were weighed. The difference was taken as the weight of the dextrin and computed on the dry basis. The percentage moisture content of the source was simultaneously obtained with the above sample of the dextrin.

In the case of the sweet potato the percentage of sucrose was determined simultaneously with the dextrin. The alcoholic filtrate with the washings from the dextrin was evaporated almost to dryness and taken up with 50 cc of water. HCl was added to invert any sucrose present and the total reducing sugars determined. The reducing sugars of the mass were simultaneously determined and subtracted from the total reducing sugars of the alcoholic residue. The difference, converted to sucrose, was assumed as the percentage of sucrose present. From the total percentage of starch converted, in the case of sweet potato, the corresponding percentage of sucrose inverted, was deducted, to compensate for the apparent increase in the sugar content due to its inversion.

TABLE 4.—Showing percentage of sucrose content of sweet potato.

Stage when determination made	Sucrose		
	X	X ₁	X ₂
	per cent	per cent	per cent
After hydrolysis.....	2.69	2.95	2.67
Inverted during hydrolysis (by difference).....	7.31	7.05	7.33

OBSERVATIONS

The inoculated mass invariably starts to soften on the second day gradually becoming less firm as the hydrolysis proceeds until about the fourth or fifth day when the entire mass becomes quite fluid. The odor was agreeably fruity. No spores were observed to develop on the mass during its period of hydrolysis.

Table 2 shows the percentages of reducing sugar in the inoculated mass, calculated on the dry basis.

Table 3 shows the largest percentages of starch hydrolyzed into reducing sugars and dextrin.

Table 4 shows the percentages of sucrose in the sweet potato that was not inverted during the period and the corresponding percentages, obtained by difference, of the inverted sucrose.

Organisms X and X₂ are fairly strong hydrolyzers. X₁ is comparatively weak.

With regards to the substratum, rice yields consistently the highest starch inversion for the three microorganisms, while sweet potato, the lowest, except in the case of X₁ growing on cassava.

The highest reducing sugar content is given by rice with X₂, while the highest dextrin content is yielded by cassava with X₁.

The highest total inversion yield is by rice with X₂ while the lowest total yield is by cassava with X₁. Without this last which is a notable exception, the general behavior of the organism X, X₁ and X₂ towards their corresponding substratum are fairly constant.

In the same substratum, if an organism produces more dextrin, a corresponding decrease in reducing sugars is generally noted.

After a certain degree of starch conversion has been reached, the percentage of reducing sugars invariably starts to diminish. This observation and the reason why the starch in different materials are not uniformly hydrolyzed will be the subjects for separate study.

SUMMARY

Certain strains of the *Neurospora crassa* are good starch hydrolyzers.

Rice yields the most hydrolisate followed by cassava and corn and lastly by sweet potato.

In the same substratum, generally, the more the dextrin the less the reducing sugars.

Yenko and Umali: Starch Hydrolysis

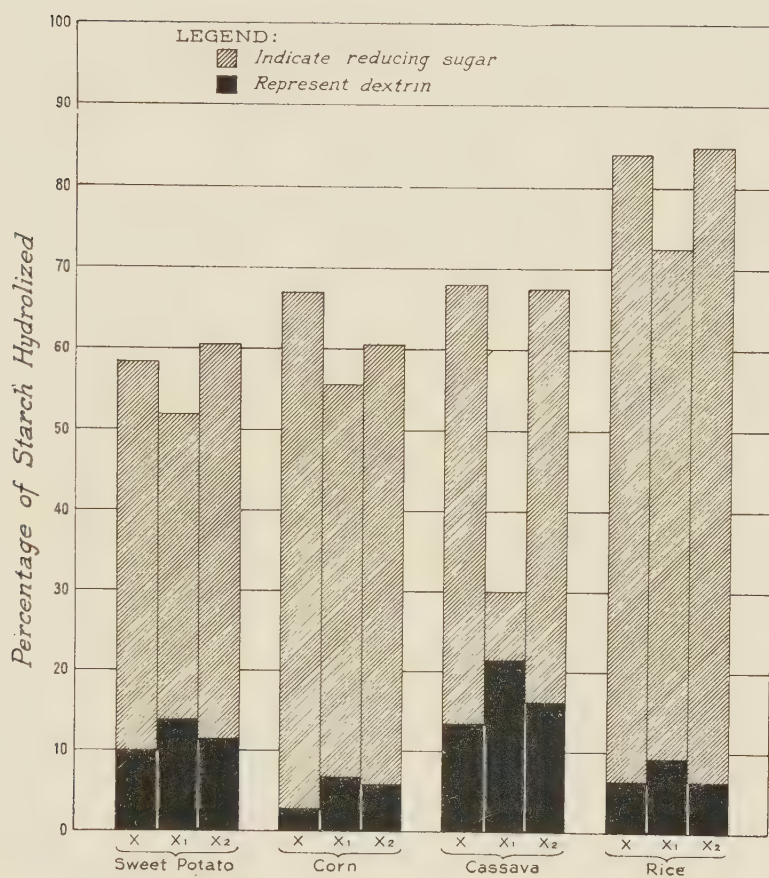


Fig. 1.

TWO NEW GENERA OF MYRMECOPHILOUS STAPHYLINIDÆ FROM THE PHILIPPINES

By CHARLES H. SEEVERS
Of the Chicago Natural History Museum

ONE PLATE

The purpose of this paper is to record two new genera and species of Staphylinid beetles associated with Doryline ants of the genus *Aenictus*. These interesting guests were discovered by Dr. James Chapman who devoted much time to the study of Philippine ants while Professor of Biology at Silliman University, Dumaguete, Negros Island. Dr. Chapman expects to publish his observations on the behavior and ecology of *Aenictus*, including notes on the relationships of these beetles to the ant colony. Much has been written about the dramatic behavior of the driver ants (*Dorylus*) of Africa and the army ants (*Eciton*) of the American tropics, but little information has been available about the more obscure Dorylines of the genus *Aenictus*.

One aenictophilous Staphylinid has heretofore been recorded from the Philippines, the very bizarre ant-mimic, *Aenictoteras chapmani* Wheeler, discovered some years ago by Dr. Chapman. Indeed, that species is the only Staphylinid beetle so far recorded with Doryline ants in Asia, Australia, or the Pacific Islands. By contrast, numerous remarkable species from Africa and the Americas have been described. Dr. Chapman's discoveries indicate that *Aenictus* colonies are also promising niches for investigation.

Aenictoxenus gen. nov. belongs to the Staphylinid subfamily Pygosteninae, a relatively small group of species which occurs with Doryline ants in Africa and fungus-growing termites (Macrotermitinae) in Indo-Malaysia. *Aenictoxenus* is closest to *Doryloxenus*, an interesting genus with fifteen species living with Doryline ants in Africa and nine termitophilous Indian and Javan species. Other genera of the subfamily (*Pygostenus*, *Sympolemon*, etc.) are African Doryline guests. Three genera of Sumatran Staphylinids have been placed in the Pygosteninae (*Delibius* Fauvel, 1899; *Deliodes* Casey=*Delius* Fauvel, 1899; and *Xynidius* Rey, 1886), but inasmuch as they were not collected with ants there is no evidence that they are myrmecophilous. There is no good evidence that they belong to the Pygosteninae. *Aspidobatrachus claviger* Sharp (1888) from Japan

is also included in this subfamily; its habits are unknown, but on the basis of its peculiar facies Sharp thought that it was probably myrmecophilous or termitophilous.

It is noteworthy that *Aenictoxenus chapmani* sp. nov. and the termitophilous Javan species, *Doryloxenus triarticulatus* Kemner, were observed riding on the bodies of their hosts. Kemner [Ent. Tidskr. 50 (1929) 220] figured the tiny beetle on the head of a termite and Dr. Chapman will describe in more detail the behavior of *A. chapmani* in this respect.

The second new genus, *Aenictobia*, is a member of the Staphylinid subfamily Aleocharinae, and falls in the large and heterogeneous tribe Myrmedoniini that is characterized only by the tarsal formula (4, 5, 5 segmented) of its members. Within this tribe there is apparently a natural group of dorylophilous species comprising many African and American genera. It is at present difficult to delimit the group inasmuch as the available information consists largely of isolated generic descriptions and because the Old and New World species have been treated quite independently. When this group is defined and delimited it will doubtless contain *Aenictobia* and *Aenictoteras* Wheeler, as well as other undiscovered Pacific area genera. No attempt is made to place *Aenictobia* among its American and African relatives at present, but it is noteworthy that *Ecitonidia* Wasmann of the southern United States is surprisingly close.

The writer is much indebted to Dr. James Chapman for the privilege of studying these interesting species. The holotypes are in the Chicago Natural History Museum and paratypes in the collections of Dr. Chapman and the writer.

AENICTOXENUS gen. nov.

Aenictoxenus chapmani sp. nov. Type. Small in size; body fusiform (Pl. 1, fig. 2) but broader and more compressed than *Doryloxenus* (Pl. 1, fig. 3). Head broad, convex; dorsum expanded laterad and cephalad to form broad "eaves" which completely conceal the eyes, mouthparts, and antennal fossae; apical margin of head broadly arcuate and feebly explanate. Antennal fossae, eyes, clypeus, labrum, and mouthparts visible only in ventral view (Pl. 1, fig. 1).

Antennae 8-segmented (Pl. 1, fig. 1); segments 2 to 8 compact, fusiform; 2 to 7 short and transverse, terminal segment elongated, compressed. Gula, submentum, and mentum broad and short. Labial palpi 3-segmented, minute. Maxillary palpi

4-segmented; second segment slender and spindle-shaped; third segment longer and broader than second, wider at apex than base; fourth segment elongated, slender, cylindrical.

Pronotum (Pl. 1, fig. 2) transverse, strongly convex, its hypomera very large; anterior margin almost straight, basal margin slightly arcuate. Elytra (Pl. 1, fig. 2) short; apical margins almost straight; apical angles not produced; epipleurae large. Metasternum very short. Anterior coxae large, convex, contiguous. Femora broad, their apices with thin laminae enclosing the bases of the tibiae. Tarsi 4, 4, 4 segmented.

Abdomen very broad at base, its sides converging strongly to the slender apex; dorsum almost flat; paratergites broad.

Remarks.—Distinguished from *Doryloxenus* by its distinctive head (the *Doryloxenus* head is narrow and the eyes are visible from above, unless concealed by the pronotum); its 8-segmented antennae (11-segmented in *Doryloxenus*); broader and more dorso-ventrally compressed body (compare Pl. 1, figs. 2 and 3); different form of pronotum and elytra (compare Pl. 1, figs. 2 and 3); the very short metasternum (large in *Doryloxenus*).

AENICTOXENUS CHAPMANI sp. nov.

Plate 1, figs. 1-2.

Type and two paratypes from Luzuriaga, Negros, Republic of the Philippines; two paratypes from Dumaguete, Negros, May 24, 1949, July, 1949; collected by Dr. James Chapman.

Host.—*Aenictus martini* Fabricius; determined by Dr. Chapman.

Length, 1.3 mm. Color testaceous. Head, pronotum, and elytra strongly shining, with only the faintest trace of extremely fine punctules; abdomen with moderately dense, asperate punctules. Head, pronotum, and elytra almost devoid of pubescence; except for traces along the lateral margins of pronotum and elytra, and on pronotal hypomera and elytral epipleurae; dorsum of abdomen rather densely clothed with pale, recumbent hairs. Head, pronotum, and elytra with numerous macrosetae as in Pl. 1, fig. 2; pronotal hypomera with a row of four and elytral epipleurae with two macrosetae. Tergites with a subapical row of 8 to 10 setae; paratergites setose; sternites with an apical row of about fourteen semierect, pale setae.

AENICTOBIA gen. nov.

Aenictobia longicornis sp. nov. Type. Head (Pl. 1, figs. 4, 5) slightly longer than broad; its dorsum somewhat saddle-like

in appearance; occiput convex, slightly swollen laterally, its sides almost perpendicular; vertex broadly and shallowly concave behind three prominent protuberances, one above each eye and one at middle, the three connected by lower ridges. Front of the head vertical; the medial protuberance of vertex continued ventrad as a narrow clypeal keel that narrowly separates the deep antennal fossae. Antennae inserted below the low ridges connecting the vertexal protuberances; their insertions relatively close together, separated by one-fourth the width of head. Eyes large, somewhat bulbous in appearance. Postgenae with narrow ridge-like elevations behind eyes, and shallowly concave below, causing the formation of ridges that parallel the gular sutures. Gula long and moderately broad, twice as long as submentum. Mentum and submentum about equal in length. Maxillae small; maxillary sinuses small. Maxillary palpi 4-segmented; second segment slender at base, wider at apex, but less than one-half as wide as long; third segment longer than second, triangular in outline, base very narrow, apex about one-half as wide as length; fourth segment slender, about three-fifths as long as third. Labial palpi 3-segmented; long and slender, the second segment smaller than the others. Antennae very long, capable of reaching the middle of abdomen; all segments elongated.

Pronotum with the disk convex and its sides explanate; hypomera entirely visible from side; apical border straight, apical angles broadly rounded; sides almost straight; base very strongly arcuate for most of its width, but straight for a short distance near each rectangular basal angle. Pronotal disk with a shallow concavity before the middle. Elytra generalized.

Prosternum keeled. Mesosternum short. Mesocoxal acetabulae narrowly separated; the bluntly rounded mesosternal process comprising one-third and the more slender metasternal process two-thirds of the intercoxal isthmus. Legs moderately long; femora and tibiae of middle and hind legs each about as long as elytra; legs generalized; tarsi 4, 5, 5 segmented.

Abdomen one-sixth wider than elytra; dorsum almost flat, the paratergites forming an elevated margin; sides of abdomen scarcely converging, the seventh segment not much narrower than preceding segments; venter convex.

Remarks.—*Aenictobia* belongs to a section of the tribe Myrmedoniini (Aleocharinae) comprised of guests of Doryline ants; its closest known relatives are probably guests of *Eciton* in the Western Hemisphere. It is not feasible at present to make a detailed comparison of this genus and its American relatives,

but the head structure is distinctive enough to separate the genus.

AENICTOBIA LONGICORNIS sp. nov.

Type and seven paratypes from Dumaguete, Negros, Republic of the Philippines; collected May 3, 1949, May 7, 1949 (some without dates) by Dr. James Chapman. Two paratypes from Horns of Negros, Negros Island (3,600 ft. elevation; no date).

Host.—*Aenictus laeviceps* Smith; determined by Dr. Chapman.

Length, 2.4 to 2.5 mm. Color reddish-brown. Dorsum without macrosetae; sternites with a marginal row of pale erect hairs and a few other setae. Head, pronotum, and elytra granulose in appearance, with numerous fine granules on the intervals between frequent setigerous punctures (the hairs of head and pronotum minute and inconspicuous, those of elytra longer). Tergites and sternites with a dense vestiture of fine, recumbent hairs. Antennal segments with approximately the following proportions (length : width)—scape (20:10), 2 (10:8), 3 (14:6), 4 (13:6), 5 (15:7), 6 (15:7), 7 (15:7), 8 (15:8), 9 (15:8), 10 (15:9), 11 (25:9); one unit is equal to .009 mm.

REFERENCES

- BERNHAEUER, M. and K. SCHUBERT. Coleopterorum catalogus, 5, pars 67, Staphylinidae [Pygosteninae (1916) 444-447].
CAMERON, MALCOLM. The fauna of British India. Coleoptera. Staphylinidae 3 [Pygosteninae (1932) 320-326; *pl. 3, fig. 7*].
SCHEERFELTZ, OTTO. Coleopterorum catalogus, 6, pars 129, Staphylinidae [Pygosteninae (1933) 1473-1478].
WASMANN, E. Zur Kenntniss der Gäste der Treiberameisen und ihrer Wirthe am obern Congo. Zool. Jahrb. Suppl. 7 (1904) 611-682, *pls. 31-33*.
WASMANN, E. Wissenschaftliche Ergebnisse einer Forschungsreise nach Ostindien. V. Termitophile und myrmecophile Coleopteren. Zool. Jahrb. Syst. 39 (1916) 170-210, *pls. 4-5*.

ILLUSTRATIONS

PLATE 1

- FIG. 1. *Aenictoxenus chapman*—ventral view of head.
2. *A. chapmani*—dorsal view.
3. *Doryloxenus collari* Cameron—dorsal view.
4. *Aenictobia longicornis*—dorsal view of head.
5. *A. longicornis*—front view of head.

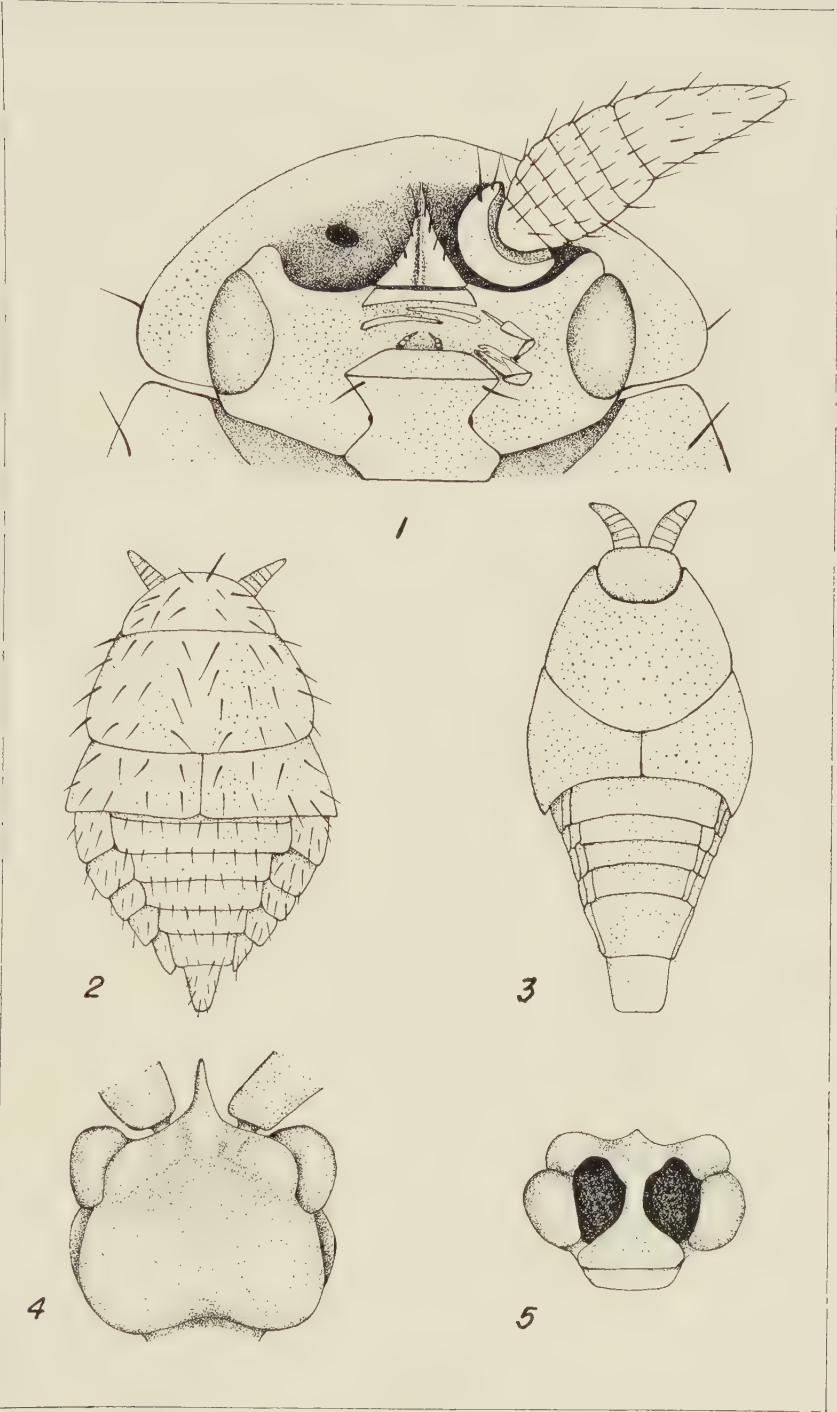


PLATE 1.

TWO NEW SPECIES OF ACANTHACEAE FROM THE PHILIPPINES

By C. E. B. BREMEKAMP
Botanisch Museum, Utrecht

SEMNOSTACHYA LEYTENSIS Brem., sp. nov.

Inter congeneres foliis nec crenato-dentatis nec ciliatis, inflorescentiis sine pilis capitatis, bracteis bracteolisque et calycis lobis minutissime sed densissime glanduloso-punctatis, antheris mucronatis instructas spicis brevibus, bracteis angustis et corolla magna cognoscenda.

Herba ramosa, ramis patentibus, circ. 1 m alta. Caulis ramique primum praesertim in sulcis densius ferrugineo-pubescentes, deinde glabrescentes, primum obtuse quadrangulares, internodiis bisulcatis, deinde subteretes, verruculosi. Folia opposita subaequalia vel inaequalia, in petiolum sulcatum, sulco excepto breviter ferrugineo-pubescentem, 4–6 mm longum contracta; lamina lanceolata, foliorum superiorum quae sola nota usque ad 6 cm longa et 1.9 cm lata, apice caudato-acuminata, basi contracta, margine remote calloso-denticulata, sicc. plus minusve nigrescens, supra glabra, subtus costa nervisque sparse pubescens, cystolithis praesertim supra conspicuis, nervis utroque latere costae 2–5. Inflorescentiae spiciformes 2.5–3 cm longae, solitariae; pedunculus internodiis rachidis plerumque subaequilongus, densius ferrugineo-pubescentem; rachis etiam ferrugineo-pubescentem. Bracteae lineari-lanceolatae, obtuse exeuntes, inferiores usque ad 2 cm longae et 3.5 mm latae, apicem versus in caudam contractae, coriaceae, extus densius ferrugineo-pubescentes et minutissime sed densissime glanduloso-punctatae, margine ciliatae, 3-nerviae. Bracteolae ad calycis tubum adnatae, lobis similiores sed paulo majores, 1.4 cm longae et 1.7 mm latae, ceterum ut bracteae. Calyx tubo 3 mm alto, lobis 11 mm longis et 1.0 mm latis, vix conspicue 3-nerviis, ceterum ut bracteae bracteolaeque. Corolla circ. 4 cm longa, extus glabra, tubo 9 mm longo, faucibus circ. 2.5 cm longis, lobis emarginatis 8 mm longis. Filamenta staminum longiorum dimidio inferiore hirtella, 6 mm longa, staminum breviorum glabra, 3 mm longa; antherae 2.7 mm longae, mucronatae, thecis subaequalibus. Staminodium parvum. Granula pollinis virgis 18 instructa, 75 μ alta et 50 μ diam. Ovarium pilis ecapitatis longe comosum, Stylus basi sparse hirtellus. Capsula nondum visa.

LEYTE, Ormoc, Mt. Mamban, summit, alt. 1,163 m, *Phil. Nat. Herb.* 12154 G. E. Edaño, type.

This species is easily distinguishable from the other Philippine species by the shortness of the spikes, the narrow bracts and the large flowers.

RUNGIA PODOSTACHYA Brem., sp. nov.

Spicis longe-pedunculatis, laxis a congeneribus distinguenda.

Herba decumbens, ad nodos inferiores radicans. Caules subteretes, circ. 1.5 mm diam., primum bifariam pubescentes, deinde glabrescentes, internodiis 5–8 cm longis. Folia in petiolum breviter pubescentem circ. 5 mm longum contracta; lamina plerumque lineari-lanceolata, foliorum aliquorum linearis vel ovato-lanceolata, 3.5–5.0 mm longa et 0.7–1.9 mm lata, apice obtusa vel subobtusa, basi subacuta, margine subundulata, discolor, sicc. vix discolorata, utrinque glabra, nervis utroque latere costae 4 vel 5. Spicae terminales et pseudo-axillares, i.e. solitariae ad nodos, pedunculo gracili bifariam pubescente 1–6 cm longo instructae, rachide 1.5–4 cm longa, pubescente, internodio infimo haud raro flore longiore, aliis gradatim brevi-oribus. Bracteae steriles triangulares, 3 mm longae et basi 0.8 mm latae, 3-nerviae, anguste hyalino-marginatae, ciliolatae; bracteae fertiles sterilibus paulo majores, 4 mm longae et basi 1.1 mm latae, margine hyalino vix conspicue latiore. Bracteolae ovato-ellipticae, 4 mm longae et 2 mm latae, late hyalino-marginatae, breviter aristatae, dense ciliatae, costa parce ciliolata, 1-nerviae, intus glandulis rubris minutissime sparsae. Calycis lobi 3 mm longi, basi 0.5 mm latae, graciliter ciliatae. Corolla alba tubo 2.5 mm longo, labio superiore 3 mm longo et 2.6 mm lato, inferiore 4 mm longo et 4 mm lato, lobo mediano 1.5 mm longo et 2.3 mm lato. Stamina filamentis minutissime glandulosis 1.8 mm longis, thecis 1 mm longis. Granula pollinis 25 μ alta et 16 μ diam. Ovarium glabrum 1 mm altum. Stylus glaber 3 mm longus. Capsula glabra 3 mm longa et 1.7 mm diam. Semina carunculata.

MINDANAO, Davao Province, Mt. Kampaliki, alt. 700 m, *Phil. Nat. Herb.* 11542 G. E. Edaño, type.

Easily recognizable by the long peduncle.

A NEW RECORD OF HEMIRHAMPHID FROM THE PHILIPPINES

By ARTEMIO M. SARENAS AND INOCENCIO A. RONQUILLO
Of the Bureau of Fisheries, Manila

ONE PLATE

EULEPTORHAMPHUS LONGIROSTRIS (Cuvier)

Hemi-Ramphus longirostris CUVIER (1817) 186, Paris.

Hemirhamphus macrorhynchus CUVIER and VALENCIENNES (1846) 55,
pl. 556, Paris.

Euleptorhamphus macrorhynchus SEALE (1902) 19, Honolulu.

Euleptorhamphus longirostris JORDAN and EVERMANN (1905) 128,
fig. 43, Honolulu, Hawaii; Formosa Island.

Hemirhamphus longirostris GÜNTHER (1909) 358, Pondicherry
(India).

This species is here added to the Philippine fauna on the basis of six specimens turned over to the Philippine Bureau of Fisheries by the Philippine Fishery Program of the U.S. Fish and Wildlife Service. These specimens were captured by night-light operations (catching fish by dip net at the surface with the aid of light hanging on the side of the fishing vessel) of the research vessel *Spencer F. Baird*, in the following stations:

Station	Locality	Lat. N.	Long. E.	Depth	Date	Hours	S. L. (mm)	N M No.
B-131	Celebes Sea.....	2°00'	124°00'	2750	3:4:48	2000-2145	220.0	2161
B-312	Bancolan Is. Sulu Sea.....	7°57'	118°55'	1200	7:15:48	2005-2115	2 specimens 172.0;180.0	2162
B-375	West of Cotabato, Mindanao Island -	7°00'	123°49'	1600	9: 4:48	2055-2315	257.6	2163
B-415	NW Celebes Sea----	6°00'	123°00'	2500	9:15-16:48	2235-0110	185.0	2164
B-466	Off Panay Island----	10°44'	121°55'	7	11:20:48	2000-2200	124.1	2165

Measurements and counts.—Measurements in per mille of standard length based on six specimens 124.1 to 257.6 mm (average 189.8 mm.) in standard length; length of head 137 (129-142); interorbital space (measured to edge of the expanded frontals 12 o'clock from orbits) 38 (32-41); length of snout 45 (39-47); diameter of orbit 39 (33-43); length of maxillary 35 (31-37); distance from dorsal to ventral 101 (96-108); distance from dorsal to anal (measured between bases of first exposed rays) 76 (61-81); distance from snout to pectoral 162 (151-167; distance from snout to dorsal 681 (671-694; distance from snout to ventral 620 (596-660); depth of body (measured between pectoral base and extreme posterior border

of opercle) 69(58–74; least depth of caudal peduncle 29(27–30); length of exposed dorsal base 256(252–259); length of exposed anal base 224(216–241); vertical distance from dorsal body margin to pectoral insertion 18(15–21); vertical distance from ventral body margin to upper end of pectoral insertion 53(44–59); length of pectoral 233(222–246); length of ventral 37(32–40).

Fin formula: D.22(21–22); A.21(21–22); P.I–7; V.6.

General form.—Body very long and moderately compressed, the lower half from horizontal axis somewhat more flattened than dorsal, the middle of back with a subcarinate ridge clearly discernible anteriorly. Head compressed, parietals depressed, clearly lower than the prominently elevated frontals, dorsal and ventral body contours similarly behind base of pectoral, tapering to a moderately slender caudal peduncle.

External body details.—Head naked; entire body covered by very deciduous scales, moderate and gradually diminish in size antero-posteriorly. While those below the body axis are relatively much larger than those along the dorsal, they are most often hardly visible due to the blending color with the skin along that region; no scaly fin flaps; lateral line running very low almost touching ventral body margin, originating just below the lower border of the opercle, branching off directly below base of pectoral forming an oblique angle with the main (lateral) line which extends to caudal base.

Head.—Eye moderate in size, orbital diameter about as long as length of snout. Nasal cavity moderate, one pair directly in front the dorsal fourth border of orbit, upper edge forming a part of the dorsal profile of head over the base of snout, a well developed fleshy flap seemingly bisecting cavity clearly visible; pupil oval. Gill opening large, gently rounded, its descending curve more abrupt posteriorly; gill membrane not united; isthmus a rather long thin narrow frenum. Mouth small, very strongly superior, lower jaw produced into a long slender beak about 512 per mille of standard length, markedly greater than any member of the genera belonging to this particular family (Hemirhamphidae). Maxillary curved inward; broadly expanded and bluntly rounded posteriorly, length approximating diameter of orbit. Teeth in small villiform bands on the jaws and vomer; tongue rather thick, flattened, fleshy, and little free in front and around edges. Pseudobranchia absent, gill rakers denticulate, short and heavy but tips sharply pointed except the distal first two or three (first arch) on

dorsal branch which are short, bluntly rounded and hardly discernible. $7 + 0 + 20(19-22)$ on first arch, length of gill raker immediately below angle 3.8 (3.2-4.4) diameter of orbit.

Fins.—Dorsal far behind posterior third of body, 22 soft rays, origin on a perpendicular about half the diameter of orbit way in advance from base of first anal ray. Pectoral insertion high, upper end base about thrice as close to dorsal body margin as to ventral margin, its length approximating length of dorsal base. Anal base slightly less than dorsal, in a vertical about an orbital diameter behind dorsal origin. Ventral about a preopercular length from anal, midway between pectoral base and tip of shortest caudal ray. Caudal forked, lower lobe markedly larger than the upper which is a distinguishing characteristic of the caudals of true flying fish (Exocoetidae). It is rather interesting to note that *E. longirostris* was seen to have flown no less than 150 feet in the air (Myers 1950) in the Bikini Atoll, Marshall Islands.

Coloration.—Color in life pale bluish-silvery, the narrow edges of scale pockets on dorsal pigmented brownish-black; the scales appearing as if pigmented. A very conspicuous lateral bluish-black band from about 0.5 to 0.25 times as thick as the body depth, running to caudal and lying about a millimeter or two below the dividing line between the pigmented dorsal region and the non-pigmented ventral half, leaving a rather slaty silvery band just above it (main band); bill bluish-black; fins pale bluish save the whitish anal and the upper lobe of the caudal which has a diffuse curved black band parallel with the edge.

Color in alcohol, dull grayish brown, the narrowly but distinctly brownish-black pigmented edges of fallen scale pockets clearly discernible, lateral band more or less dull brownish-black; all the fins somewhat olivaceous gray, anal and ventrals very much lighter or dull whitish.

Previous reports showed occurrence of this particular species in the following localities: Pondicherry (India) after Kuddera of Russell; Open Sea (Paris) 177°C , 7°S ; Hawaiian Islands, Peyster Island (Polynesia); Formosa Island.

LITERATURE CITED

- FOWLER, HENRY W. The fishes of Oceania. Bornice P. Bishop Mus. Mem. 10 (1928) 74.
- GÜNTHER, ALBERT C. L. G. Catalogue of the Fishes in the British Museum 6 (1866) 276.

- JORDAN, D. S. and B. W. EVERMANN. Fishes from Formosa. U. S. Nat. Mus. Proc. 25 (1903) 329.
- JORDAN, D. S. Fishes of Hawaiian Islands. U. S. Fish. Comm. Bull. 23 (1905) 128-129, fig. 43.
- MILLER, ROBERT R. *Hyporhamphus patris*, a new species of hemirhamphid fish from Sinaloa, Mexico. U. S. Nat. Mus. Proc. 96 (1945) 185-193, fig.
- MYERS, GEORGE S. Flying of the halfbeak, *Euleptorhamphus*. Copeia 4 (1950) 320.



PLATE 1.

A BIRD NEW TO PALAWAN

By DEAN AMADON

Of the American Museum of Natural History, New York

In 1910 the American Museum of Natural History, New York, purchased a small collection of bird skins obtained on Palawan by Colonel John R. White. This collection contains a specimen of the Black-eared Kite, *Milvus migrans lineatus* taken at Iwahig, Palawan, on December 1, 1907. It is a female in worn immature plumage. This specimen, apparently the first to be recorded from Palawan or the Philippines, is now No. 96150 in the collection of the American Museum. The Black-eared Kite nests in Siberia and adjacent areas and winters chiefly on the mainland of southeastern Asia from Korea south. It has been recorded from Borneo, and now from Palawan, so it is possible that migrant individuals occasionally straggle to the Philippines.

PHYSIOGRAPHIC OBSERVATIONS ON MINDANAO BY AERIAL RECONNAISSANCE, AND THEIR GEO- LOGICAL INTERPRETATION ¹

By EARL M. IRVING
Geologist, U. S. Geological Survey

INTRODUCTION

ONE PLATE AND ONE TEXT FIGURE

In late November, 1951, a team of Philippine and American government engineers and officials undertook extensive aerial reconnaissance of Mindanao for the purpose of locating additional arterial road systems in order to stimulate agricultural

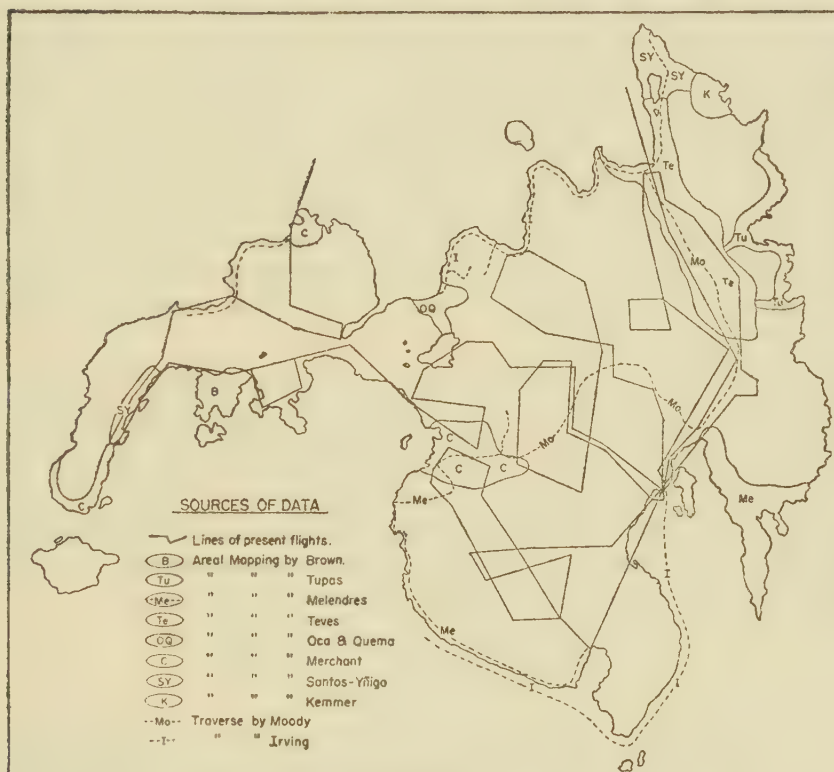


FIG. 1. Sources of data for present paper.

and industrial development of the island. For five days the party averaged approximately four hours in the air in an airplane provided by the Philippine Air Force. As seen in Fig. 1, the island was crossed and recrossed many times.

¹ Published with the permission of the Director, U. S. Geological Survey.

Because of the irregular equant shape of the island, and owing to its well-known inaccessibility, the broader physiographic and geologic features of the interior have long been enigmatic to both geologists and geographers alike. Except for occasional deeply penetrating traverses by American geologists in the early part of the present century and recent regional studies by Glenn F. Brown (1950) on the Sibuguey Peninsula, by J. S. Teves (1951) along the Agusan Valley, by M. Melendres (1950) on the Davao Peninsula, by L. Santos-Yñigo along the Zamboanga Peninsula, and by Dr. Mateo Tupas in the Lanao area, geologic investigations to date have been limited essentially to widely scattered, local, mineralized areas near the coasts. In such heavily forested and undeveloped terrains as these, it is difficult to discern regional physiographic relationships and aerial reconnaissance provides an especially favorable tool to observe them from a perspective not frequently available to earth-bound investigators. Plate I, which is a composite topographic map developed from several sources of information, especially from aeronautical charts (No. V30-42, 5th Edition, 1951) of the U. S. Navy, from available topographic maps of 1:50,000 scale of the U. S. Army Map Service, and from sounding charts of the U. S. and Philippine Coast and Geodetic Survey, attempts to portray the broader physiographic features of the island.

The writer as a member of the team is indebted to the Philippine Air Force for having supplied an airplane for such a long period, as well is he obliged to officials of the U. S. Economic Cooperation (now Mutual Security Administration) for having been invited as a member of the reconnaissance group. The present paper summarizes physiographic data and includes geological information gathered from available sources that support, or lend meaning to, the interpretations.

PRINCIPAL PHYSIOGRAPHIC UNITS

COASTAL PLAINS

Coastal plains are of very limited width and length along the coasts of Mindanao. They are best developed at those few points where principal stream valleys emerge upon the coasts, such as: The Agusan River Valley at Butuan on the north coast; the Cagayan and Tagoloan River Valleys on the north-central coast; the Hijo and Tagum River Valleys at the head of Davao Gulf; the Cotabato River Valley and Basin on the west-central coast; the Titay and Sibuguey River Valleys at the head of

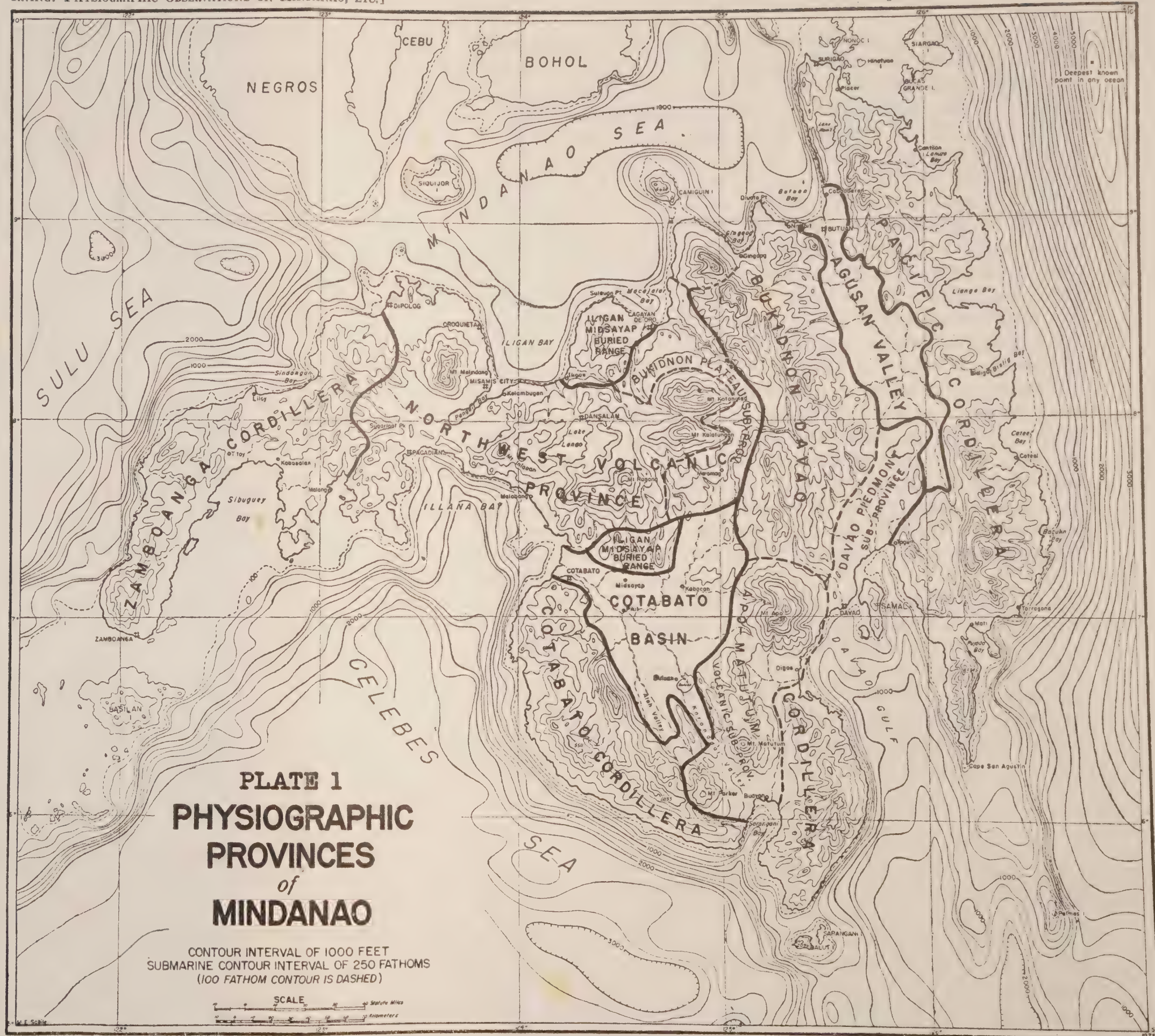


PLATE 1.

Sibuguey Bay, and the Salug River Valley at the head of Panguil Bay, in western Mindanao. The broad, sloping piedmont plains south of Dipolog and north of Misamis City on the other hand, are constructional volcanic slopes.

Most of these surfaces adjoining the coasts are mainly surfaces of construction that are built up as the shoreline progrades seaward by deposition and reworking of material carried to the sea by neighboring rivers. The outer part of such coastal areas is often characterized by extensive mangrove swamps. Immediately inland from the coastal mangrove zone, there is frequently a parallel zone of swamp lands of varying dimensions, which are economically important for artificial fish pond development. In the neighborhood of the rivers themselves in these areas, oxbow lakes, representing abandoned segments of meander cut-offs, are commonly present, sometimes in profusion. Most rivers are strongly meandering in their lowermost segments upon approaching the coasts. Further inland the valley surfaces rise to provide extensive, flat to gently rolling, moderately well-drained, areas for agriculture.

At several points along the coast, as northwest of Davao, north of Cagayan de Oro, west of Butuan City, and near Zamboanga City, there are local plains that represent uplifted surfaces of marine plantation. These are commonly floored by coralline reef materials. Elsewhere, where uplift has been greater, the coasts are bordered by hilly and hummucky areas that represent uplifted fringing coral reefs in varying stages of subaerial erosion and dissection.

It may be said, however, that a large proportion of the coasts of Mindanao is characterized by quite steep profiles, often by actual sea-cliffs, for long distances. This tends to indicate that the island is predominantly rising along its margins, although as will be shown on a later page, large areas in the interior have been or are subsiding.

MOUNTAIN RANGES AND CORDILLERA

From topographic considerations and sketchy geological information, the island possesses at least four well-defined cordillera or mountain ranges of folded type: (1) the north-south trending Pacific Coast Cordillera, (2) the north-south trending central Bukidnon-Davao Cordillera extending from Sipaco and Diuata Points between Cagayan de Oro and Butuan Cities on the north, to the tip of Sarangani Peninsula on the south, (3) the northwesterly trending Cotabato Cordillera that extends from near Cotabato City to Sarangani Bay and borders the

Celebes Sea coast, and (4) the northeasterly trending cordillera of the Zamboanga Peninsula extending as far north as near Dipolog. A fifth cordillera of low elevation that is discerned on structural grounds, is largely buried by the volcanic superstructure of the Lake Lanao volcanic region. The northernmost and southernmost ends of this belt of basement and folded rocks emerge from beneath the volcanics in the area northeast of Iligan on the north, and west of the port of Parang, near Cotabato, on the south.

The great Pleistocene to recent volcanic clusters of western Mindanao such as Katalungan and Katanglad of Bukidnon Province, Makaturing and Ragang of Lanao Province, Malindang of Misamis Occidental Province, Sugarloaf of northern Zamboanga Province, and finally Mts. Apo, Matutum, and Parker, west and southwest of Davao are youthful prominences resulting from geologically recent volcanism, and accordingly are the result of processes different from those responsible for the lineal cordillera. These will be described under subsequent heading.

The Pacific Cordillera.—The Pacific Cordillera is situated along the eastern seaboard and occupies large parts of Surigao and Davao Provinces of Mindanao. The cordillera rises to maximum heights near its two extremities, at Mt. Hilonghilong (elev. 6,028) east of Butuan, on the north, and at Mts. Tagdalit and Tagubud (elev. 8,207) west of Baculin Bay on the south. Between these two principal mountain masses, the range descends to surprisingly low elevations in its middle part, especially west of Lianga and Bislig Bays. West of these bays, valley-like passes that cross over into the Agusan Valley are less than 1,000 feet in elevation. Individual mountain masses in this area, however, rise to elevations of three to five thousand feet.

Another low pass across the cordillera is found between Lupon and Mati, at the upper or northern part of Davao Peninsula. Thence southward the peninsula rises to maximum heights at Mt. Hamiguitan (elev. 5,345), midway down the peninsula. From this summit, the cordillera descends to Cape San Agustin, and in a sense, continues southward as a submarine ridge of major relief above the average level of the adjacent ocean floor.

The northern end of the Pacific Cordillera, especially in the Surigao gold mining district (Santos-Yñigo, 1944) and further south, in the vicinity of the lateritic iron ore deposits (Frasché, 1941), are known to be composed mainly of pre-Eocene schists,

gneisses, and metamorphosed volcanic rocks containing interbedded metamorphosed sediments. These are intruded by peridotite (now rendered largely to serpentinite) and by occasional small masses of gabbro and diorite. These rocks, collectively referred to as "basement rocks" or "basement complex," are overlain by Eocene nummulitic limestone, Miocene graywackes, shales, limestones and volcanics, and Pliocene sandstones and volcanics. The youngest period of folding has involved Pliocene sediments, accordingly it must be concluded that the cordillera in this area has been uplifted in the late Pliocene or Pleistocene time. Extensive north-south faulting related to the Philippine Rift Zone (Irving, 1951), moreover, is clearly expressed in the topography west of Lake Mainit and along the western base of the range southward, indicating that earth movements have continued to fairly recent dates geologically.

Further south in the vicinity of Bislig (Alberding, 1939 and Tupas, 1950), coal-bearing Miocene sandstones and shales overlie a great thickness of volcanics that may be lower Tertiary to pre-Tertiary age. The coal-bearing sequence is moderately folded and the included coal has been raised to bituminous rank, accordingly principal uplift of the range in this area has occurred at least in upper Tertiary time.

The southern massif is composed (Melendres, 1951) mainly of metamorphosed volcanic and sedimentary rocks that are extensively intruded in the headwaters of the Hijo River, by quartz diorite and granodiorite. These basement rocks are overlain by Eocene (?) manganiferous cherts west of Mati, by coal-bearing Miocene sandstones and shales near Tarragona, and by Pliocene conglomerates and sandstones along the west slopes of Davao Peninsula. Again it is presumed that uplift in this portion of the range was late Tertiary to Pleistocene. Powerful faulting resulting with a fresh, little modified, east-facing scarp, is observed along the west shore of Pujada Bay south of Mati. On physiographic grounds the Philippine Rift Zone appears to pass along the western side of the southern mountain mass and joins the Pujada fault zone, and thence passes out to sea with a southeasterly course.

The Bukidnon-Davao Cordillera.—This cordillera is the longest, most continuous, and including the volcanic mountains, ascends to the highest elevations of any of the cordillera of Mindanao, and in fact may be considered the principal medial geologic structure of the island. F. M. Merchant (Corby, 1940) has referred to it as the "Central Cordillera." However, the present

terminology is used to assign its position in readily identifiable geographic terms; other geologists may wish to retain Merchant's denomination.

Beginning on the north, the cordillera is complex, that is, the range that is typically of the folded range type is superposed locally by volcanic structures, and these culminate at Camiguin Island off the coast. In the area east of Cagayan de Oro, the range bifurcates and extends to the two prominent peninsular points, Sipaca and Diwata, and results with the irregular trace of the coast between Butuan City and Cagayan de Oro. Between the two peninsular points is a broad, but short, valley of steep gradient that lies at the head of Gingoog Bay. In the area of bifurcation, the cordillera is 30 miles wide and maximum summit elevations ascend to between 8 and 9 thousand feet. The eastern slopes of the range descend gently to the Agusan Valley on the east; the western slopes descend sharply to the tuff-capped mesas of the Bukidnon Plateau on the west. The summit area consists of great north-south trending mountains altering with deep longitudinal V-shaped valleys, especially those containing the headwater segments of the Pulangui River, a principal tributary to the Mindanao River. It is covered by dense rain forest and undoubtedly is one of the most forbidding, inhospitable, and inaccessible areas of the island. From this area the cordillera, still retaining multiple north-south trending ridge summits, descends gradually southward to a point west of Davao.

West of Davao, the cordillera again becomes complex. The central part of the folded range proper becomes buried beneath, and superimposed by the great volcanic mass that culminates in Mt. Apo (elev. 9,690'). This volcanic mass is elongate in north-south direction and its apex appears to coincide approximately with the axis of the folded range which it apparently buries. Rocks of the older folded range become exposed again west of Digos and continue in a sinuous pattern southward to the end of Sarangani Peninsula. Another low pass across the range occurs south-southwest of Digos. Mt. Matutum (elev. 7,524') and Parker Volcano (elev. 5,697') are other large volcanic cones that have been built up mainly west of the axis of the folded range. The area covered by the volcanic rocks of Mts. Apo, Matutum, and Parker which are extinct Pleistocene-recent volcanoes, is delineated as a subprovince of the Bukidnon-Davao central cordillera area, in order to distinguish it geologically from the folded range proper.

East of this cordillera and north of Davao is a low rolling area that can hardly be called a part of the cordillera, but on the basis of geologic structure it is clearly a part of it. In a sense the area is a salient of the Bukidnon-Davao Cordillera that projects eastward and the north-south axes of folding and faulting may indeed extend so far as to bridge this cordillera across to the Pacific Cordillera. This is the Davao Piedmont subprovince which is an extremely productive agricultural area; the broad, low valleys of the Saug, Libuganon, and Tuganay Rivers provide exceedingly rich soils for the cultivation of abaca. Highest elevations (Mt. Ampaoid, elev. 3,497') are found along a sharp rise southwest of the Agusan Valley, and from this point the surface slopes gently southward, and from the Bukidnon-Davao Range, eastward.

The geology of this great cordillera is the least known of any part of Mindanao. Few geologists appear to have made observations or conducted traverses across or along it. At Diwata Point west of Butuan City, Teves (1951) reports the presence of folded Miocene sandstones and shales, and these are overlain in the Nasipit Bay area and along the west side of the Agusan River valley by Pliocene sandstones and shales. Plio-Pleistocene coral reefs floor the Agusan Valley west of Butuan City. From this evidence folding and uplift of the range may be ascribed to upper Pliocene diastrophism.

The rocks cropping out along the road around Sipaca Point were observed by the writer in 1947 to consist mainly of youthful volcanics, and from the air, the larger part of the peninsula appears to possess volcanic topography. In the area east of Cagayan, however, the land forms are more characteristic of comparatively homogeneous rocks, and it is supposed that the range there, and continuing southward, is composed mainly of rocks of basement type. In the deep canyons of the Tagoloan River southeast of Cagayan, basement rocks have in fact been reported by Ickis (Smith, 1924, p. 209). These are overlain by flat-lying tuffaceous sediments and locally by limestones that form the mesas and plateaus that characterize the Bukidnon Plateau region. These tuffaceous sediments appear to have been deposited close upon and perhaps in part have buried, the westernmost foothills of the cordillera. From this evidence, uplift of the cordillera at least predates the later phases of volcanism that produced the Katanglad and Katalungan volcanic clusters. In other words, principal diastrophism accounting for the present elevation of the range must have occurred in the late Pliocene to perhaps early Pleistocene time.

In 1924, Mr. George B. Moody, as a part of his Mindanao investigations, made a traverse from near Tagum at the head of Davao Gulf following the Libuganon River upstream, crossed the cordillera at the latitude of $7^{\circ}30'$, and then passed down the Pulangi River. On the resulting map (S.E.S. Folder No. 144), he shows the range to be composed of parallel alternating belts of Tertiary sediments and basement rocks which are brought in contact by major faults with trends more or less consonant with the trend of the range.

No field observations have been made in the region from opposite Digos to the tip of the Sarangani Peninsula. While passing along the coast by interisland steamship in 1949, the author was able to make out in the great barren sea cliffs that the formations are moderately well bedded, that they are moderately to strongly folded, and that the axes of folding appear to be northeasterly, i.e. the present coast transects the axes of folding. From a distance of 1 to 3 kilometers the rocks appear to be clastic sediments interbedded with volcanic breccias, agglomerates, and perhaps tuffaceous sandstones and tuffs. From the air the rocks appear to be soft types that weather easily, producing soft, smooth surface profiles. Except near the southern end of the peninsula, this part of the cordillera appears to be lacking in superposed volcanic cones or prominences. Balut Island to the south is largely volcanic while the adjoining Sarangani Island is much lower and appears to be composed of volcanics overlain by uplifted coral reef materials.

Cotabato Cordillera.—The Cotabato Cordillera forms a single unbroken mountain chain extending for 200 kilometers in arcuate pattern from near Cotabato City to Sarangani Bay. At Sarangani Bay, one might presume that the cordillera continues across and joins the Bukidnon-Davao Cordillera at its southern end on Sarangani Peninsula. This, however, appears not to be the case, for, upon examining the submarine configuration of the bay, it is found that the bay occupies a sharply discordant trench that descends rapidly to depths of 4 to 5 thousand feet. The eastern and western walls of the trench are exceedingly steep-sloped and are relatively straight. Considering that much of the area adjoining the bay is characterized by extensive recent volcanism, which of course is constructional, the sub-aerial and submarine form of the bay is unusual and one might reasonably presume that the bay, and accordingly the southeastern apparent end of the Cotabato Cordillera, is influenced

or determined by faulting, perhaps by multiple faults that result with a graben. Equally as peculiar and fascinating are the excessively steep offshore submarine profiles in the Celebes Sea adjoining the Cordillera; evidence for the cause of these, however, is slender although major faulting or powerful upwarping may be contributing factors.

The northeastern face of the Cordillera facing the Cotabato Basin is quite regular and except for a rolling foothill area in the vicinity of Talayan, the range front rises sharply from the gently sloping floor of the Cotabato Basin. The range front opposite the village of Magonoy is especially impressive, and rises sharply to elevations of over 6,000 feet. This is also true for that part opposite Alah Valley particularly in the vicinity of Sebu Lake where its overflow descends over precipitous slopes and offers extraordinarily favorable opportunity for hydroelectric power development.¹ Toward the southeastern end of the range, the configuration becomes complicated where a long low ridge projects northwestward and separates Alah Valley from Koronadal Valley. West of Lake Baluan, this ridge gradually descends and disappears beneath the alluvium of the Cotabato Basin.

As indicated before, the seaward face of the range is also very abrupt, and rises sharply from the coast. In general the coastal plain is narrow and much of the coast, particularly north of Lebak, is fronted by steep cliffs. Occasional deep canyons penetrate sharply into the interior.

Observed from the air, the surface profiles of the range are generally smooth, although the deep interior is very rugged. Having received reports that the range contains abundant volcanic rocks, special attention was directed to determine to what extent Pleistocene to recent volcanism may have played in the formation of the range. Surprisingly, very few recognizable volcanic cones are observed and if they do exist, erosion appears to have largely destroyed their external forms. Mt. Parker (5,697') situated southwest of Koronadal, and which contains Maughan Lake, as well as nearby Sugar Loaf Peak (6,002'),

¹ The significance of this opportunity for power development does not seem to be appreciated by the authorities. At the present time, and doubtless even more so in the future, there is a heavy surge of settlers moving into the basin. Early power development not only encourages settlement, but more importantly, it would foster development of this vast area along modern rather than along present outmoded patterns. The importance of timing should not be overlooked.

are partially denuded volcanoes, although this could not be determined readily from external forms alone. Volcanic pyroclastic debris is reported (Francisco and Comsti, 1950) to form the outer northern and eastern slopes of the extreme southeastern end of the cordillera. Elsewhere the range appears to be devoid of youthful volcanic forms and it is believed that the reported abundant volcanic rock types may represent older volcanic formations, perhaps of Tertiary age, that have been folded and faulted into their present positions of high elevation.

Melendres (personal communication) reports that the northwestern end of the range is composed of Tertiary volcanics overlain by Awang limestone (Pliocene) both of which are moderately to strongly folded. At Linao Point, north of Linao Bay, basement rocks composed of highly folded and distorted, thin-bedded, gray quartzites crop out. Thence southward, the range appears to be composed largely of Tertiary-type volcanics although the central maximum summit area (5,000') is reported to be capped by karsted limestone, possibly Awang limestone.

The Palimban and Kling Rivers, Melendres further reports that besides numerous volcanic boulders, also carry boulders of diorite and granodiorite. At Cablacan Point volcanics and lower Miocene limestones are observed in complex structural relation. At Kamanga and along the Seguil River, west of Sarangani Bay, quartzite schist, chert, and massive quartzite are found to pass beneath the Mt. Parker volcanics.

Referring to Plate 1, it is noted that a very prominent river (Mao?) descends from the north flank of the range at a point south of the barrio of Mao, and that the headwater segment forms a prominent longitudinal valley in the interior of the cordillera. This feature, together with ridge summits elongated parallel to the axis of the cordillera, further leads one to the conclusion that the range is of tectonic origin and is the result of folding.

From available information the range therefore is composed mainly of basement rocks, middle Tertiary sediments, large volumes of Tertiary volcanics, and these are overlain around the north end of the range by Awang limestone of Pliocene age. If the Awang limestone itself is moderately folded as reported by Melendres, and if it caps the south central summit area, principal uplift of the range was evidently in late Pliocene to Pleistocene time. Volcanism at the extreme southeastern end of the mountain chain must be of similar age.

The Zamboanga Cordillera.—This cordillera of northeasterly trend extends from Zamboanga City at the southern end of the Zamboanga Peninsula to southwest of Dipolog at which point the folded rocks of the range pass beneath the youthful volcanics of the Northwest Volcanic Province to be described shortly. The topographic axis of the range does not pass as a medial line down the peninsula but is displaced westward toward the western or Sulu Sea side. And exceptionally broad submarine shelf adjoins the peninsula on the southeast side and extends to and joins the Sibuguey Peninsula; its low elevation and its great breadth, comparable to the width of the peninsula itself, further emphasizes the asymmetrical cross-profile of this portion of the isthmian ridge that joins Mindanao to Borneo.

As in the case of the Pacific Cordillera, maximum elevations are found near the extreme ends of the cordillera, southwest of Dipolog (max. elev. 3,720') and immediately north of Zamboanga City (max. elev. 4,380'). In the middle portion of the cordillera, elevations descend much lower than those conveyed on most maps; in fact in the Titay-Liloy area between Sindangan Point on the north coast and Sibuguey Bay, much of this area consists of very low, broad, valleys that are rapidly being settled by farmers. In general, the cordillera of the Zamboanga Peninsula possesses the lowest average elevation of any of the major cordillera of the island.

The range is drained by several large and numerous small streams, all of which are comparatively short and of steep gradient. With the exception of the southeastern and northern coastal plain areas, the region is sparsely populated and the mountains are largely covered by dense tropical rain forests.

The southern end of the Zamboanga Peninsula is described by F. M. Merchant (Corby, 1940) to consist of a thick sequence of Miocene sediments that have been arched into a plunging anticline in the axial portion of which, resulting from erosion, basement rocks crop out. Pliocene reef limestones overlie the more strongly deformed Miocene sediments. According to Santos-Yñigo (personal communication) similar Miocene and Pliocene sediments flank the east side of the range more or less continuously for its entire length, although upper Miocene volcanics are widespread particularly along the northern part of the east coast and extending into the interior. Little is known regarding the nature and distribution of the rocks along the western flank of the cordillera, but Santos-Yñigo reports that basement rocks, consisting of chlorite schists and amphibolite

schists intruded by diorite, metamorphosed volcanics, and metamorphosed sandstones and shales containing lenticular masses of limestone, predominate. The strike of foliation and of axes of folding in the metamorphics is variable but in general it is roughly parallel to the length of the cordillera. These basement rocks doubtless comprise the main bulk of the range along its axial region.

The northern end of the range, southwest of Dipolog, is even less well known. From the air, the region is composed of great mountains deeply dissected by sharp V-shaped canyons, and the region is densely forested. Along the north coast, L. Abad (1950) found the area to be extensively intruded by serpentine and diorite. The country rock to these intrusives, according to Merchant (Corby, 1940), are volcanics. The basement rocks in the Sindangan Bay area, according to Merchant, are overlain by Middle Tertiary limestone, marl and shales that have been folded and faulted and these, according to Abad, are overlain by still more youthful (Pliocene?) conglomerates along the coast.

From extensive mapping on the Sibuguey Peninsula by Brown (1950), the basement is said to consist of quartzites that crop out on Mt. Kaladis and in the Tres Picos area. These are overlain by Miocene limestone and by upper Miocene coal measures which have been strongly folded along east-west axes. The folded Miocene sediments are overlain by flat-dipping Pliocene Coloi sandstones and conglomerates, and by youthful volcanics.

From available evidence in three principal areas the Zamboanga Cordillera was folded toward the close of the Miocene; folding was accompanied and/or followed by extensive volcanism particularly along the east coast. After prolonged erosion, more or less flat-lying Pliocene sediments were deposited across the eroded edges of the older rock units. Brown believes that the Kaladis quartzite on the Sibuguey Peninsula may have been overthrust northward during the period of folding and Santos-Yñigo (personal communication) believes he has found evidence for eastward thrusting along the southeast coast of Zamboanga Peninsula. Although some uplift doubtless has occurred since the upper Miocene orogeny, erosion since that time has been great and may account for the lower average elevation of the cordillera.

The Iligan-Midsayap buried range.—The prominent Sulauan Point area on the north coast between Cagayan de Oro and

Iligan, is one composed of rocks quite different from the comparatively flat-lying extensive volcanics that are found to the east, south, and west, and for this reason it is an area that, on geological grounds, must be set apart. Inland from the narrow, rather swampy, coastal plain that characterizes this portion of the coast, the topography rises gently southward, although several sharp-walled valleys of gentle to low gradient descend northward to the coast. The outer part of the area is underlain by Pliocene reef limestone that is breeched in varying degrees by several streams; the limestone tends to form cliff-like escarpments along the valley walls. Further inland the gently rising reef limestones are observed to mantle an upper Miocene shale formation that also dips northward to the coast. Still further south (inland) this rolling country gives way to a ridge-valley area with interspersed meadows whose elevations vary from 800 to 1,000 feet and correspond more or less with the lower plateau-like areas of the Bukidnon plateau near Del Monte. Between the valleys and adjoining meadows, sharp ridges composed of serpentine basement rise several hundred feet above the meadow-like areas.

The west coast of the Salauan Point Peninsula is underlain apparently by the same rock units, but the topographic profiles are distinct from those of the north coast. Pliocene reef limestone underlies a low narrow strip along the coast. The Miocene shales crop out occasionally inland, and east of Mantikao they are found considerably folded and distorted. Both these rock units are generally found at low elevations. Immediately inland from the north-south outcrop belts of these two formations, the topography rises sharply along a very prominent ridge that ascends to maximum elevations of more than 2,000 feet. The ridge is composed mainly of serpentine, and it is intruded locally by gabbro and diorite. Small areas of limestone (Tertiary?) surmount the ridge locally, especially in the vicinity of the Misamis chromite mines.

South and east of the town of Iligan (Oca and Quema, 1948), a thick sequence of Miocene sandstones, shale, and limestone are found and these are strongly folded. They are overlapped by gently dipping upper Miocene and younger volcanics of the Lanao area.

From available evidence, therefore, this area is underlain extensively by basement rocks and these are overlain by Miocene sediments that are slightly to strongly deformed. The overlying Pliocene reef limestones are flat to gently dipping, ac-

cordingly it must be presumed that the region was folded in upper Miocene time. Lineation of fold axes appears to be in north-south direction.

East of Parang, and north of Midsayap near Cotabato, another area of similar rocks with similar relations crops out. In this case they are overlapped by the volcanics of the Northwest Volcanic Province on the west, north, and east sides. Southward they are buried partly by reef limestones, and more extensively by alluvium that floors the Cotabato Basin.

North of Midsayap, along the Libungan and Simuay Rivers, Merchant (Corby, 1940) found an extensive north-south belt of basement rocks composed, according to Melendres (personal communication), of serpentine. This belt of basement rocks is overlain on the west by a thick sequence of Miocene sandstones and shales that strike in north-south direction and dip steeply westward. The prominent mountain mass between the Libungan River and the Maridagao River further east is composed mainly of Miocene limestone. It also strikes north-south and appears to be in fault contact with the serpentine basement rocks. These rocks, basement and Miocene sediments, are overlapped around their southern end by the Pliocene Awang reef limestone and by alluvium. The principal period of folding, again, appears to have been in the upper Miocene.

Judging from the north-south structural lineation of rocks in the two areas, the similar date of folding in the two areas, and that by projection they lie along the same axis of folding, the two areas appear to represent windows of one and the same range that crops out from beneath the volcanics of the Northwest Volcanic Province. Tupas (personal communications) reports, moreover, that a large window of basement rocks crops out from beneath the volcanics east of Lake Lanao.

THE NORTHWEST VOLCANIC PROVINCE

Over a great area including part of Misamis Oriental Province, the western part of Bukidnon Province, the northern edge of Cotabato Province, nearly all of Lanao Province, nearly all of Misamis Occidental Province, and much of northeastern Zamboanga Province, volcanism has been excessively prominent in late Tertiary and Quaternary time. Volcanic formations ranging from upper Miocene to Pleistocene age comprise the predominant rocks of this vast region. Although the little modified original surface forms of several volcanic structures indicate that volcanism has extended up to geologically recent

dates, only three volcanoes are reported to have erupted within recorded historical time, Mt. Makaturing (1871) and Mt. Ragang (1916?) in Lanao Province, and Mt. Hibok-Hibok (1871, 1948, 1951) on Camiguin Island. The region under consideration is so large that description necessarily must be limited to units of smaller area.

Camiguin Island-Sipaca Peninsula.—Camiguin Island is situated off the coast from Sipaca Point and is approximately 40 miles due north from Cagayan de Oro. From a submarine contour map, it is noted that the island is a fairly independent mass that rises from the floor of the Mindanao Sea, from a depth of 900 to 1,000 fathoms. It is joined across to Sipaca Point at a narrow pass where the sea is only 90 fathoms deep.

The outer edge of the island is characterized by a gently sloping, irregular coastal plain. From this surface the irregular and quite broken slopes are fairly sharp and rise to two principal summit areas, Mt. Hibok-Hibok and Mt. Mambajao, with maximum elevations of 5,620 feet. The volcanic structure is not a simple one, but is multiple and rather indicates that the active vent of eruption has shifted from time to time. Present activity is limited to the northern peak, Mt. Hibok-Hibok, and is characterized by explosive eruptions in which heated pyroclastics are forced out under high pressure to form dense ash clouds. When the atmosphere above the crater becomes excessively charged with ash, the hot ash-laden clouds descend mainly as density currents (*nues ardentes*), following valleys and topographic low areas much like gigantic streams of water at flood stage. Living and inflammable objects of course are quickly destroyed when such clouds descend across or come to rest upon them. Much of the material consists of fine sand and dust although pebbles and occasional boulders are also present.

As indicated earlier, the rocks cropping out along the road following the coastline around Gingoog Bay and Sipaca Peninsula are predominantly volcanic. The outer slopes of the peninsula rise quite sharply, but regularly, to a summit at Mt. Balatocan whose elevation is variously recorded between 4,000 and 6,000 feet. It is strongly suspected that this outer mountain mass is predominantly volcanic. Other peaks further south may also be volcanic, but studies thus far have been so brief that little can be said at this time.

Several writers in the past, including the author (Irving, 1951), have suggested that a prominent fault passes along

the western base of Sipaca Peninsula and determines the rectilinear trace of its western coast. The fault is apparently an old one and may have controlled the position of the vents during the building of Camiguin Island, and possibly in some indirect way, the position of the much larger volcanic structures of Mts. Katanglad and Katalungan further south.

Mt. Katanglad, Bukidnon Province.—This great volcanic eminence is located 30 miles southeast of Cagayan de Oro and 15 miles west-northwest of Malaybalay, in western Bukidnon Province.

The outer limits of this volcanic structure extends for great distances from the ancient center of eruption, resulting that it influences or determines the topography of an exceptionally large area northwest, north, and east of the volcano. The prominent plateaus extending from the headwaters of the Iponon and Cagayan Rivers eastward through the Del Monte pineapple plantations, and southward through the Malaybalay area are underlain mainly by volcanic tuffs that doubtless originated from this center and at a time when the entire region stood about 1,200 feet lower than it does today, and when in fact the sea evidently made incursions into the area and limestones were deposited more or less contemporaneously with the tuffs locally. Late Quaternary uplift has resulted that the principal master streams have cut sharp V-shaped gorges into the outer margins of the present tuff-capped Bukidnon Plateaus. These deep incisions are well illustrated along the upper reaches of the Iponon River, of the Cagayan River, the Tagoloan River, and along the Pulangi River east and south of Malaybalay, as well as along numerous smaller peripheral streams. Basement rocks are reported by Ickis (Smith, 1924) to crop out beneath the tuffs of the plateaus, along the canyon walls.

From the rather level areas of the lower outer parts of the plateaus, the slopes gradually steepen along a smooth curve up to elevations of 4,000 feet. From this elevation upward, the surface becomes that of the volcanic cone proper, and continues to the summit, whose maximum elevation is 9,500 feet. The volcanic structure is not a simple cone, but is quite elongate in west-northwest direction, suggesting that several centers of eruption developed and were controlled perhaps by a similar-trending fissure in the underlying basement rocks.

Mt. Katalungan, Bukidnon Province.—Mt. Katalungan is a volcanic structure similar in many respects to Mt. Katanglad, and the two together form twin volcanic structures visible from

great distances. It is situated 12 miles southwest of the former and ascends to similar summit elevation, or 9,400 feet. A narrow west-northwesterly trending valley separates the two.

Like in the case of Mt. Katanglad, the air-borne tuff deposits originating from the eruptive center were carried for great distances to the east, southeast, and south, and similarly cap the plateaus and broad valleys of southern Bukidnon Province. Because the master streams, particularly the Pulangi River, have much longer longitudinal profiles, the streams are not so sharply entrenched through the tuff capping as described above, and the sharp meseta topography is less pronounced.

Mt. Katalungan, like Mt. Katanglad, is also a complex volcanic structure. The summit is quite elongate and trends in a westerly direction. It must also be supposed that growth of the structure was controlled by similarly trending fissures in the basement beneath.

Judging from their degree of erosion and dissection, the two volcanic structures are probably of similar age. Considering that these high mountain masses probably receive extraordinary high rainfall, it is difficult to believe that they have been extinct for any great period of time.

The Lanao volcanic area.—This large area comprising most of Lanao Province, extends westward from Bukidnon Province to the head of Panguil Bay where a narrow ridge connects the main body of Mindanao Island with Zamboanga Peninsula. The area includes the great volcanic cluster culminating in Mt. Ragang (elev. 9,236') southeast of Lake Lanao, the much smaller volcanic cone culminating in Mt. Iniaoan (elev. 5,204') west of Lake Lanao, and the plateau-like areas of diverse elevations northeast, north, and northwest of Lake Lanao. Lake Lanao (surface elev. 2,296') of course is a conspicuous feature of the area, although a number of smaller lakes are scattered here and there over the region.

The great Ragang volcanic cluster is situated in the southeastern part of the Lanao Province and is a center of volcanism similar in several respects to the Katanglad and Katalungan volcanic centers already described. It lies about 25 miles further to the southwest of Mt. Katalungan and is separated from it by a broad valley that contains the headwaters of the Mari-dagao River. The valley is much broader than the one between Mts. Katanglad and Katalungan. Like the Katanglad and Katalungan centers, the Ragang cluster possess a lineal summit area that varies between 8,000 and 9,236 feet in elevation, but

instead of possessing a westerly trend, the summit area trends more in east-northeasterly direction, quite different from the preceding centers. It might be supposed that the fissure structures in the basement controlling the location of these eruptive centers likewise trend in this direction. The summit area possesses several distinct volcanic centers which, from east to west, include Mt. Piapayungan, Mt. Ragang, Mt. Latucan, Mt. Makaturing, and the two small identical cones of Dos Hermanos south of Lake Lanao. Material erupted from these centers evidently poured down and outward, and in southerly direction lapped over a topography of considerable relief etched into the Midsayap portion of the Iligan-Midsayap Buried Cordillera. The surface profiles of the Ragang cluster are so youthful that their period of building must have been mainly Quaternary.

Mt. Iniaoan (elev. 5,204') is a much smaller, but well-formed, volcanic cone situated 13 miles west of the southwestern end of Lake Lanao. It appears to have been constructed upon the extensive plateau volcanics west of the lake. Its southern flank descends sharply down to the shores of Illana Bay. Its outer surface is quite dissected, accordingly it is supposed that it has been extinct for sometime.

The relation of the extensive plateau areas of diverse elevation northeast, north, and west of Lake Lanao are not clearly understood with reference to the recently active volcanic cones and clusters already described. Few central-point eruptive centers can be distinguished in this area by physiographic criteria alone, and field studies have not been conducted in sufficient detail to be able to distinguish such centers on the bases of geological criteria. It is believed tentatively, that these volcanics may represent, in part at least, accumulations from fissure-type eruptions, in other words, that they are bedded accumulations of considerable horizontal extent that have arched, folded perhaps, and faulted into their present relative positions. The geologic section exposed in the gorge of the Agus River in the vicinity of Maria Cristina Falls appears to be of this general nature, although there is a surprising preponderance of pyroclastic and agglomeratic material over the comparatively minor interbedded lava flows. The volcanics are generally andesitic to basaltic in composition. A number of olivine basalt specimens have been collected by Tupas. The plateau-like areas vary in elevation from near sea level near Panguil Bay to 4,006 feet northwest of Lake Lanao and to about 5,000 feet east of Lake Lanao. It may well be that the volcanics com-

prising there plateau areas, although perhaps belonging to the same general period of volcanism, are an older sequence and that the volcanic cones and clusters are younger and are constructed upon them. This tends to be supported by the discovery of upper Miocene and Pliocene micro-fossils in sediments interbedded with the plateau volcanics along the Iligan-Dansalan road by Merchant (Corby, 1940) and east of Parang, Cotabato Province, by the same geologist.

The origin of lake Lanao is not clear and will not be understood until detailed geological mapping is undertaken. Smith (1924, p. 210) considered that it fills "simply a basin between two well-defined mountain ranges, that have been dammed by lava flows and an unusual accumulation of wash from the hills." It is believed by the writer that its origin is considerably more complicated than this. The natural direction for overflow should be southward, yet the Agus River, flowing northward, cuts through plateau-like areas bounded by prominent escarpments. It is suspected that the basin has been, influenced strongly by faulting and may be, for instance, something of the nature of a volcanic collapse basin described by Howell Williams in many prominent volcanic areas of the world elsewhere.

Northeastern Zamboanga Peninsula.—This area of volcanics includes nearly all of Misamis Occidental Province, and the northeasternmost part of Zamboanga Province including the area south of Dipolog, north and east of Lake Wood, and much of the Margosatubig Peninsula southwest of Pagadian.

The west coast of Iligan Bay is bordered by a broad, gently sloping, somewhat gulled, piedmont surface that rises gradually inland and culminates in the great volcanic structure of Mt. Malindang (elev. 7,956'). Most older maps show a second volcano-like mass a few miles to the west that is denoted as Mt. Dapiak, with an elevation of over 8,000 feet. In flying over this region it becomes clear that the topography as shown on older maps is very much in error, and in fact that only the Mt. Malindang volcanic structure is present. Mt. Malindang itself possesses a very peculiar summit composed of numerous sharp peaks arranged closely together, and it may be that older topographers were confused by these prominences and concluded that more than the single volcanic structure exists. Mt. Malindang is a fairly symmetrical volcanic cone but is considerably eroded. Its lower basal portion is extremely broad and fertile areas for agriculture extend outward

in all directions for very considerable distances. The beautiful broad, eastward-draining Salug River Valley descending to the head of Panguil Bay is situated south of the volcano.

Southwest of the Salug River valley is Sugarloaf Peak (elev. 4,800'), another prominent but somewhat eroded volcanic cone. It is believed that this peak marks approximately the westernmost edge of the Western Volcanic Province. Thence westward the basement rocks of the folded Zamboanga Cordillera reappear.

The Margosatubig Peninsula lying between Dumaguilas and Illana Bays on the south coast is underlain mainly by youthful volcanics. Thirteen miles west of Pagadian is a sharp volcanic cone with elevation of 3,402 feet. The cone is so recent that from the air, one is able to observe a small crater lake in its summit. Another small cone (elev. 2,020') is observed 6 miles east of Margosatubig. Numerous small prominences and several small lakes that probably owe their origin to volcanism, are noted at several points on the peninsula.

STRUCTURAL VALLEYS

The Agusan River Valley.—The Agusan River Valley in eastern Mindanao is one of the least populated and least known, but most striking, valleys of the Philippine Archipelago. The Agusan River which drains it rises in the southern mass of the Pacific Cordillera, opposite Tagum, and flows in a deep V-shaped mountain canyon until it suddenly emerges upon the floor of the Compostela Basin. Next to the Mindanao River, the Agusan River if not of similar length and size as the Cagayan River of northern Luzon, is certainly at least the third largest river of the archipelago. The valley proper between Compostela and Butuan is 150 kilometers long (about the distance as from Manila Bay to Lingayen Gulf) and its greatest breadth (at the latitude of Lianga Bay on the Pacific coast) is 30 kilometers. The valley probably has an area about one half that of the Central Valley of Luzon but owing to a very large swamp in its center, its potential arable area, though large indeed, is considerably reduced. Owing to the complete absence of roads in the valley, canoes either paddled, or rigged with outboard motors, are about the only practical means of transportation within it.

The valley is not a simple one. Many of its physiographic features are the result of geological structure that express the operation of subsurface forces, some of which are operat-

ing even now. The geological features of the lower part of the valley are described by Teves (1951) who, as chief of party, recently conducted a five month geological reconnaissance for determining its petroleum possibilities. As the lower end of the valley is better known, the normal descriptive approach is reversed, and the valley will be described proceeding from its mouth towards its less known headwaters.

Where the river empties into Butuan Bay on the north, its broadly meandering course is adjoined by an extensive coastal plain that extends for many miles eastward and westward. Much of this surface parallel to the coast is progradational. The strongly alluviated surface south of Cabadbaran and extending southward to Ampayon, however, is clearly a piedmont alluvial plain built up by streams debauching from Mt. Hilong-hilong that rises so abruptly east of the valley. The linear trace and greatly oversteepened slopes of the escarpment bounding this mountain mass constitute fairly conclusive evidence that it is a fault block that has been elevated along a fault situated at its western base. This fault is considered to be one of several closely spaced, offset, and interweaving fault structures comprising the Philippine Rift Zone in this region. This particular fault loses its identity as it passes into the alluviated valley southward, but other branches of the Rift Zone come into prominence further south near Talacogon.

Immediately back of the coastal plain and south of the town of Buena Vista, Mts. Maiyapay (elev. 2,335') and Camagon (elev. 1,925') rise as rather prominent, somewhat isolated, masses that are clearly not a part of the great Bukidnon-Davao cordillera which is further to the west; surprisingly enough, they are composed of basement rock (serpentine) and are surrounded by a collar of upper Miocene clastic sediments that floor the valley in this area.

A short distance south of Butuan City, the Agusan River emerges from a low rolling, foothill area in which it is confined within a fairly narrow, rather steep-walled, gorge. The river is sharply entrenched for a distance of about 8 kilometers, and along this stretch, its course is quite straight. Further upstream the gorge becomes less pronounced and the river resumes its meandering pattern as it flows through inner valley-like areas. The latter situation is maintained for another 30 kilometers until approaching Esperanza. The foothill area adjoining and extending back many miles from the river has a relief of 200 to 400 feet and is etched in comparatively flatly-

ing Mio-Pliocene sediments, that, according to Teves, are warped locally. These sediments evidently extend back to the ranges on both sides of the valley. Clearly these marine sediments have been uplifted across the course of the Agusan River and the river is obviously antecedent in this particular section.

South of Esperanza, a comparatively broad uninterrupted floor of the main valley area opens up under the influence of the large tributary valley of the Wawa River that descends from the Diwata Mountains from the northeast. The river maintains an exceptionally strong meandering pattern for 30 kilometers further upstream until approaching Talacogon. The alluviated valley surface along this section slopes upward gently in eastward direction to the base of the Diwata range and is a fine area for agriculture; westward the level floor adjacent to the river is comparatively narrow because the wide foothill belt of the Bukidnon-Davao Cordillera tends to crowd eastward. In this connection, it should be mentioned that the foothills of the Bukidnon-Davao Range possess a persistent relationship to the adjoining Agusan Valley. The eastern slope or Agusan Valley side of this range, in contrast to the sharp range fronts of the opposing Pacific Cordillera, possesses a gentle sloping cross-profile such that the eastward flowing streams from the range are sharply entrenched and alternate with long, gently descending, finger-like interfluve ridges. The topography of this foothill area is quite hummocky and leads to the interpretation that the foothills are etched in soft formation, probably in slightly indurated upper Tertiary sediments. This general situation obtains for nearly the entire length of the western side of the Agusan Valley, and agricultural lands that can be developed will necessarily be on rolling topography. Because of the irregularity of topography, and moreover, due to the large number of small to large tributary streams that descend from the Bukidnon-Davao Cordillera, arterial road construction in this area would be difficult and costly. Most of this side of the valley, i.e. the western side, possesses a dense, tropical rain forest.

From Talacogon and extending southward almost to Santa Josefa on the Agusan-Davao provincial border, a distance of 70 kilometers, the central part of the valley is occupied by a tremendous swamp area that is much larger and more formidable than the Candaba Swamp of the Central Valley of Luzon. At the time of the present flights, it was the peak of the rainy

season, and the swamp was doubtless near maximum flood stage. At low water stages three lakes, Linao, Adgoan, and Kamarchan, are distinguished. In late November, a more faithful portrayal would be to describe the entire area as a single large swamp-like lake, and the course of the Agusan River, which flows through it, is hardly distinguishable. The basins in which the above lake result during low-water stages doubtless represent the deeper, or lowest, points of this great lowland area. The western margin, as described in the preceding paragraph, is rather sharply defined and the Bukidnon-Davao foothills approach the swamp closely. The eastern margin, because the level valley surface slopes gently toward the swamp, is less readily defined; a slight difference of water level in the swamp causes a wide shift of the strandline, particularly from season to season. Owing to the swampy conditions in the central part of the valley of course, the alignment of any arterial road through the valley necessarily will have to be located along the foothill belt to the east.

The origin of this vast swamp area is of peculiar geological interest. Because the formations in the valley proper are mainly sedimentary, it cannot be said that it is the result of damming by recent volcanic activity. As pointed out earlier, the section of the river between Butuan and Las Nieves was shown to be an antecedent, that is, that this portion of the valley has been elevated and the river has maintained its course despite that the foothill area on both sides were elevated above it. It might be said accordingly that diastrophism in the lower part of the river's course has caused damming upstream from it. As mentioned before, the foothill area is composed of Mio-Pliocene sediments; Teves shows that these sediments are gently folded into anticlines and synclines near Las Nieves, and that north of Talacogon, they are both folded and faulted. The age of the folding and faulting, however, is not given; accordingly we do not know how recently this disturbance took place. If it is of recent date, this hypothesis could be a reasonable explanation for the swamp area in the Talacogon-Santa Josefa section.

On the other hand, it is also to be noted that the river possesses no rapids or falls; rather, its channel is moderately deep such that shallow draft boats are able to ascend as far as Las Nieves and Esperanza. Moreover, the river possesses a strongly meandering pattern throughout most of its course. These facts indicate that the river's course is fairly well ad-

justed, and that the velocity of current is primarily a matter of volume of water moving through the channel. These data to the writer's mind would indicate that damming may not be the answer; it is possible that the actual subsidence may be going on in the area of the swamp. It should be noted that the numerous large tributaries descending into the swamp area, from all sides, are carrying substantial volumes of sediments into it. Over a comparatively short period of time, a swamp resulting from damming alone would be filled quickly; on the other hand, a swamp area whose floor is gradually subsiding would be of comparatively long life. To obtain a final answer on this problem of course detailed field investigations are required.

Upstream from Santa Josefa, there is a notable sharp constriction of the valley which is caused by the sudden development of prominent highland area on both sides of the river's course comparable in some ways to that between Butuan and Esperanza. This highland, as mentioned in connection with the description of the Davao Piedmont sub-province, rises sharply at latitude $8^{\circ}00'$ and culminates in Mt. Ampaoid, and then slopes generally southward toward the Davao Gulf. The Agusan River, upon passing through the highland area again adopts a rather straight course for 15 kilometers until Moncayo, which is situated on the northern, or lower edge, of the Compostela Basin.

The Compostela Basin is a very striking valley area, about 15 kilometers long in north-south direction, 8 to 10 kilometers wide, and is hemmed in by foothills and mountains on all sides. It possesses a comparatively level, smooth, floor that slopes generally toward the river. It is now being settled vigorously for the cultivation of abaca. In upstream direction, from the Compostela Basin, the Agusan River again enters into a sharp V-shaped mountain valley of the southern mass of the Pacific Cordillera.

The unusual topographic relations between Santa Josefa and Compostela, wherein the Agusan River first passes through a narrow valley etched through a highland area and in upstream direction again passes through a small basin, and yet again enters into the V-shaped valley of the southern mountain mass, are not well understood. Although Tertiary volcanics are known to exist in this area, no Pleistocene to Recent volcanism is known or expressed. The region is reported to consist mainly of folded and faulted Tertiary sediments and volcanics. Base-

ment rocks doubtless crop out locally. One must conclude that the physiographic history of the upper end of the Agusan River valley has been long and probably complex. If the Philippine Rift Zone persist through this area, as it is believed, faulting and corresponding movement of blocks has probably influenced its topographic development considerably.

Before concluding, it should be stated that there is a very distinct drainage divide between the Salug River, that drains into the head of Davao Gulf, and the Agusan River drainage west of the Compostela Basin. This is not well shown on most maps and one may be led to believe that the Salug River taps the Compostela Basin; it does not.

STRUCTURAL BASINS

The Cotabato Basin.—The Cotabato Basin comprises an immense lowland area in northern Cotabato Province that is hemmed in by the Iligan-Midsayap range and the mountainous Northwest Volcanic Province on the north, by the Apo-Matutum volcanic sub-province of the Bukidnon-Davao Cordillera on the east, and by the Cotabato Cordillera on the southwest. It is drained by a single major river system, that of the Mindanao River; this river system is the largest of the Philippine Archipelago. The basin has two natural outlets to the sea, that near Cotabato City where the Mindanao River flows into the sea, and a pass-like exit to the southeast, consisting of the Koronadal Valley, whose continuation leads out to the port of Buayan on Sarangani Bay. The Cotabato Basin possesses large undeveloped, level agricultural areas that are hardly appreciated by most Filipinos. Like the Agusan Valley just described, the central part of the basin is occupied by a large swamp that similarly reduces its effective potential arable land area.

The basin possesses an irregular outline owing, additionally, to the influence of recent volcanism upon the topography adjacent to it; if the effects of this volcanism are discounted, the basin would have a quite different form. The eastern margin of the present basin doubtless would be further east and the northeastern reentrant of the basin would extend considerably northward toward Macajalar Bay on the north coast. In other words, the depression would not be a basin strictly, but rather an irregular depression lying between the three folded ranges immediately contiguous to it.

The southwestern margin of the basin is determined by the Cotabato Cordillera. As said before, the flat level floor of the basin approaches the range front very closely, and the

range front rises abruptly along a gently curving trace. The southeastern part of the basin is composed of two very large and prominent valleys, the Koronadal and Alah Valleys, that are separated by a long slender ridge probably composed of folded rocks whose axis of folding is sympathetic with those of the Cotabato Cordillera.

The eastern margin of the basin appears to be determined by volcanics of the Apo-Matutum subprovince, although no geological work has been done in the area. It is conceivable that folded rocks of the Bukidnon-Davao Cordillera crop out beneath the youthful volcanics.

The northeastern reentrant area that follows the Pulangi River system is a foothill area that, from available information, is underlain by folded Tertiary sedimentary and volcanic rocks which are overlain unconformably by outliers of recent volcanics that cap the higher ridges. This region also has escaped attention by geologists.

The northern edge of the basin is determined by the Iligan-Midsayap Buried range at the southern end of which, the rocks composing the range are overlapped by Pliocene Awang limestone and by valley alluvium.

The western outlet of the basin displays some of the features of the lower end of the Agusan Valley. The Mindanao River flows through a comparatively narrow inner valley. Beyond the walls to the north and south of this inner valley, foothills rise several hundred feet. At the coast, several isolated hills are found whose summit elevations are comparable to those of the foothills. These upland areas are composed mainly of Awang Pliocene limestone, although west of Midsayap, a rather large area of youthful, unconsolidated boulder conglomerates are also found. These relations strongly suggest that uplift has taken place since the Pliocene, and that the Mindanao River has maintained its course while uplift has gone on, in other words, the river is antecedent in this part of its course.

The origin of the swamp in the central part of the basin has not been established. At the time of the flights, the swamp was more than 20 kilometers wide and possibly 50 kilometers long. Judging from the very low gradient of the Mindanao River in this part of its course, the swamp area is doubtless very little above sea level. Because the floor of the valley is so level, there must be great variation in size of the swamp depending on the season of the year. Uplift near the mouth of the river could be considered as a partial cause, but as in the

case of the Agusan River Valley, the course of the Mindanao River is well adjusted and it is presumed that subsidence is a principal factor in its development.

Lake Lanao Basin.—As already mentioned briefly, Lake Lanao is enclosed in a small basin near the summit of a broad volcanic plateau area of the Northwest Volcanic Province. The lake's surface is 2,204 feet above sea level and from reports, parts of the lake are very deep.

On the east and south sides of the lake, a fairly level surface several kilometers wide is intensely farmed. South of this surface of course the Ragang volcanic cluster rises sharply. To the east and northeast irregular sharp cliffs rise 1,500 to 2,000 feet above the plain and in which the edges of horizontal to gently dipping structures may be seen. To the north, several prominent escarpments of diverse trend are observed in which similar gently dipping bedding structures of the volcanics can be discerned. West of the lake the mountains descend quite sharply down to its shore. The highlands northwest and northeast of the lake rise to elevations of four to five thousand feet and as seen from the air consist of rather level, gently undulating surfaces, that are rather characteristic of volcanic plateau surfaces.

Smith (1924) believed that the lake formed as a result of damming of river valley by lava flows. It is quite clear, however, that the basin in which the lake occurs formed by a more complicated process. In the first place, the basin is more or less of equidimensional shape. Neither the lake nor the basin in which it is situated possesses a pattern comparable to a subaerial drainage system. Moreover, no river valley of similar dimensions exists elsewhere in this region. The depression, therefore, is a distinctive, isolated, topographic feature of the region. If the depression is not the result of erosion, then one may reasonably ask what happened to the projected portions of the beds exposed in the cliffs west, north, and northeast of the lake basin.

It is proposed, as an alternative explanation, that the beds corresponding to those exposed in the escarpments, by projection, have been dropped down by faulting, i.e. that the basin is essentially a large collapse basin of structural origin. Of course the exposed excarpments are now somewhat eroded, and south of the lake, the form of the basin has been modified by recent constructional volcanism.

This alternative hypothesis requires additional field confirmation but it is believed to be a more plausible conclusion than that advanced by Smith. It is possible that some relationship exists between the withdrawal of magmas to form the nearby Ragang volcanic cluster, and subsidence of the basin.

Lake Mainit Basin.—Lake Mainit is located near the northern tip of the Surigao Peninsula, northeastern Mindanao. The lake possesses an area of 40 square kilometers and its elevation above sea level is 82 feet. The basin is underlain, and on the north, east, and south is adjoined by folded Tertiary sediments and volcanics; on the west it is bordered by abruptly rising slopes of the western range that, in this area, are composed mainly of basement rocks (serpentine).

From previous geological mapping, it is fairly well established that the linear western range of the Surigao Peninsula is a fault block uplifted between two major faults of the Philippine Rift Zone. From the results of recent field work, Teves (1951) believes that Lake Mainit is situated in a graben basin developed between the fault along the eastern base of the range, and a third north-south fault that lies east of the lake. This hypothesis seems reasonable and is tentatively accepted.

REFERENCES

- ALBERDING, H. Coal resources of the Liñgig-Bislig District, Surigao, Mindanao. Private Report for National Development Company, 1929.
- BROWN, G. F. Summary of the geology of the Malangas-Sibuguey Coal-field, Zamboanga Province, Mindanao. *Philip. Jour. Sci.* **79** (1950) 155-163.
- CORBY, G. W., *et al.* Geology and oil possibilities of the Philipines. Manila, Bureau of Mines **9** (1940), in press.
- FRANCISCO, F. U. and F. A. COMSTI. Limestone and guano resources of southern Cotabato and Maramag, Bukidnon. *Phil. Bur. Mines, M. S.* (1950).
- FRASCHÉ, D. F. Origin of the Surigao iron ores. *Econ. Geol.* **36** (1941) 280-305.
- IRVING, E. M. Submarine morphology of the Philippine Archipelago and its geologic significance. *Philip. Jour. Sci.* **80** (1951) 55-88.
- MELENDRES, M. and F. A. COMSTI. Reconnaissance geology of southeastern Davao. *Phil. Geologist* **5** 2 (1951) 38-46.
- OCA, G. and J. C. QUEMA. Summary report on the Agus River hydro-electric power projects, Maria Cristina, Lanao, Mindanao. Private report for National Power Corporation, 1948.
- SANTOS-YÑIGO, L. Geology of the Surigao Gold District, Mindanao. *Phil. Bur. Mines, M. S.* (1944).

- SMITH, W. D. A geologic reconnaissance of the Island of Mindanao. Philip. Jour. Sci. § A 3 (1908) 473-498.
- SMITH, W. D. Geological reconnaissance of Mindanao and Sulu. Part II, Physiography. Philip. Jour. Sci. § A 5 (1910) 345-363.
- SMITH, W. D. Geology and mineral resources of the Philippines. Department of Agriculture and Commerce, Manila, 1924. 559p.
- Strategic Engineering Studies Folio No. 144, Mindanao. Prepared by U. S. Geological Survey for Corps of Engineers, U. S. Army 1944. 125 p.
- TEVES., J. S. Reconnaissance geology of Agusan. Phil. Geologist 5 4 (1951) 24-40.
- TUPAS, M. H. Mineral resources of southern Surigao (Liangá, Hinatuan, Bislig, Liñgig). Mineral News Service. Phil. Bur. Mines, Dec. 1950. 4 p.

BOOKS

Books reviewed here are received and acknowledged from time to time by The Philippine Journal of Science.

Elementary Problems in Engineering (First Printing). By H. W. Leach and George C. Beakley. New York, The MacMillan Company, 1951. 269p. \$3.50.

The role of engineering in our national growth and industrial development is gaining more and more importance. The increasing complexity of our problems in everyday living, brought about by the advance of civilization, demands more and more the aid of the engineer in their solution.

This book gives a bird's eye view of the general scope encompassed by this profession. It lays forth a brief, compact survey of the course, to acquaint a new student with the basic ideas about engineering work. These basic ideas serve as stepping stones to further development of civilization by the control and utilization of the forces, materials and energy so generously supplied by nature.

The authors are cognizant of the fact that intangible virtues are necessary for success in any line of endeavor. These virtues, to name a few, are integrity, industry, initiative, perseverance, personality and such other characteristics. However, in addition to these general requirements, one who would take engineering should be endowed with facility in mathematics and the physical sciences. Similarly, another measure of engineering aptitude is an interest and knowledge of physics, chemistry and general science. As the title of the book implies, elementary problems along these lines are laid forth with a view in mind to give prospective engineers a better idea of the nature of the engineering profession.

The book is profusely illustrated with pictures and diagrams.

The authors are Professors of Engineering, Tarleton State College.—M. F.

A Course in General Chemistry: Semi-Micro Alternate Form. Third Edition. By William C. Bray, Wendell M. Latimer and Richard E. Powell. New York, The MacMillan Company, 1950. 217p. Price \$3.00.

The book is intended not only to teach chemistry but also to provide students with a scientific training. To attain these ends the authors have presented the principles of general inorganic chemistry through a series of logically connected lab-

oratory experiments. Numerous questions and problems were introduced to emphasize essential points. This is important as it increases the interest of the student and develops self-reliance by putting him upon his own responsibility in doing the work and interpreting the results.

The fundamentals of systematic separation were developed by starting with the study of the properties of a few ions as well as the methods to separate them. After these principles are mastered, additional ions are added to the scheme. This was found to be a more satisfactory method for the correlation of experimental facts and principles.

An important feature of the book is the introduction of semi-micro techniques and the pictorial presentation of laboratory techniques.—S. S. T.

THE PHILIPPINE JOURNAL OF SCIENCE

Manuscripts intended for publication in The Philippine Journal of Science should be sent to the Editor, The Philippine Journal of Science, Institute of Science and Technology, Manila, Philippines.

Manuscripts on biology must be accompanied by abstracts for publication in the Biological Abstracts.

Fifty separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

Publications sent in exchange for The Philippine Journal of Science should be addressed: Scientific Library, Institute of Science and Technology, Manila, Philippines.

CONTENTS

	Page
MANALO, JUAN. Mariano Gatdula Basaca	73
BASACA, MARIANO G. Production of yeast from molasses	75
COPELAND, EDWIN BINGHAM. Grammitidaceae of New Guinea	81
YENKO, FLAVIANO M. and PAULINA UMALI. Starch hydrolysis by Neurospora	121
SEEVERS, CHARLES H. Two new genera of myrmecophilous Sta- phylinidae from the Philippines	125
BREMEKAMP, C. E. B. Two new species of Acanthaceae from the Philippines	133
SARENAS, ARTEMIO M. and INOCENCIO A. RONQUILLO. A new record of hemirhamphid from the Philippines	135
AMADON DEAN. A bird new to Palawan	139
IRVING, EARL M. Physiographic observations on Mindanao by aerial reconnaissance, and their geological interpretation	141
BOOKS	171